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VOL. II NO. 6

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. II June, 1918 No. 6

Joint Meeting with the NATIONAL GAS ENGINE ASSOCIATION

THE first joint meeting of the Society and the National Gas Engine Association was held on June 4 at the Hotel Sherman, Chicago. The N. G. E. A. sessions were held on June 3 and 4, concluding with a technical session conducted jointly with the Mid-West Section of the Society on the afternoon of the 4th and with a dinner on the evening of the same day.

The dinner was attended by nearly 200 members of both organizations, G. W. Smith, chairman of the Mid-West Section, acting as toastmaster. The principal speech of the evening was made by O. H. Fischer, president of the National Gas Engine Association. Mr. Fischer described the labor situation on the Pacific Coast, and said that the labor problem is one of the most important that must be settled if the war is to be waged successfully. John Van der Vries, of the Chamber of Commerce of the United States, described the activities of the chamber, and Field Secretary R. E. Plimpton of the Society spoke in regard to the relation of the N. G. E. A. and the Society.

W. L. Derry, president of the National Federation of Implement Dealers' Association, addressed the convention on Monday morning. During the afternoon a paper on the labor situation as affecting the manufacture of engine parts, written by W. E. Blair, general manager of the Buffalo Gasoline Motor Co., Buffalo, was read in the absence of Mr. Blair. This was followed by an address on the necessity for the utmost economy in the use of coal by Joseph Harrington, representing the Federal Fuel Administration, and by a paper by S. F. Lentz, lubrication engineer of the Texas Company, New York, on the conservation of gas engine fuel as effected by lubricating oil.

The evening session was a war-service meeting, William Butterworth, president, Deere & Co., Moline, Ill., delivering an address entitled "War Service Committees and Their Purposes." Mr. Butterworth gave an interesting account of what had been accomplished by the Implement Manufacturers' War Service Committee in eliminating wagon sizes and in setting prices.

On Tuesday morning, following the annual election of officers (when Mr. Fischer was reelected), the following papers were scheduled: The Future of the Farm Engine Business in View of the Tractor Eliminating the Portable and Larger Sizes, by Albert Stritmatter of the Chilton Company, Philadelphia; and the Present and Future of the Gas Engine Export Trade, by Orme Fetterly of Dun's International Review, New York. A round-table discussion as to the best number of sizes of engines to manufacture was led by Theo. Menges, who exhibited a series of charts showing commercial tendencies evidenced by the farm engines now on the market. It was voted to refer this matter to the Stationary and Farm Engine Division of the S. A. E. Standards Committee.

The papers read at the joint technical meeting of the Mid-West Section of the S. A. E. and the N. G. E. A. on Tuesday afternoon were Ignition Apparatus on the Modern Farm Engine, by H. R. Van Deventer, works manager, Sumter Electrical Co., Sumter, S. C., and The Hvid Engine and Its Relation to Poppet and Diesel Types, by C. B. Blakely, chief engineer of Sears, Roebuck & Company, Chicago. There was a long and spirited discussion after Mr. Blakely had presented his paper, many of the members asking questions regarding the performance of the Hvid engine. This discussion will be printed in a later issue of THE JOURNAL.

Meeting of Stationary and Farm Engine Division

Coincident with the convention, the Stationary and Farm Engine Division of the S. A. E. Standards Committee met on Tuesday, June 4, those in attendance being Charles Kratsch (chairman), Theo. Menges, L. S. Keilholtz, F. J. Lemeley, S. M. Walker, Field Secretary R. E. Plimpton, and R. S. Burnett of the S. A. E. Standards office.

The first subject considered was the adoption of a simplified series of stationary and farm engine sizes. The May, 1918, Bulletin of the N. G. E. A. contains a summary of the various engine sizes listed in the 1918 specifications of stationary and farm engine manufacturers. This showed that the 1½, 3, 4, 6, 8, 10 and 12-hp. sizes were the most popular. These sizes have already been generally adopted by many manufacturers as standard sizes. This summary indicated that thirty different sizes are sold by fifteen different makers. The Division will consider carefully the present sizes, to see if some of them can be eliminated.

New Subjects

The following list of subjects was suggested for consideration. In order to commence active work on each subject, assignments were made as follows:

1. Present N. G. E. A. Standards	Mr. Kratsch
2. Screws, cap-screws, set-screws, studs, threads, nuts and lock washers	Mr. Walker
3. Piston rings and grooves	Mr. Walker
4. Piston pins and bushings	Mr. Walker

DINNER OF NATIONAL GAS ENGINE ASSOCIATION AND SOCIETY OF AUTOMOTIVE ENGINEERS, SHERMAN HOTEL, CHICAGO, JUNE 4, 1918

5. Crankshaft diameters and extensions for pulleys	Mr. Lemeley
6. Valves and valve collars	Mr. Walker
7. Connecting-rod proportions	Mr. Walker
8. Pipe flange (oval and round)	Mr. Menges
9. Flanges for cast iron carbureters	
10. Engine mounting dimensions for portable truck installations	Mr. Lemeley
11. Cylinder lubricators and grease cups	Mr. Walker
12. Adaptability of present S. A. E. Standard engine testing forms	Mr. Keilholtz
13. Voltage and capacity ratings of farm lighting outfits	
14. List of suitable present S. A. E. Standards and Recommended Practices	

It is planned that each Division member will review the present S. A. E. Standards and Recommended Practices and submit a list of those suited to stationary and farm engine practice at a later meeting of the Division. Mr. Menges stated that S. A. E. threads have not been used by stationary engine builders, and that it would probably be advisable to adopt the U. S. Standard. He also said that at present S. A. E. lock washers have not proved satisfactory for stationary and farm engine practice. It was suggested that S. A. E. standard carbureter flanges should be revised for use with cast-iron carbureters. When using the present standard flanges for cast iron, too many drill bits and taps are broken, as the tools cut into the pipe wall when the holes are drilled and tapped.

The second meeting of the Stationary and Farm Engine Division was scheduled for Saturday afternoon, June 15, at the Engineers' Club in Dayton.

Activities of S. A. E. Sections

A LARGE number of officers of the Sections as well as members of the Sections Committee held a conference during the Dayton meeting of the Society. At this conference a proposed manual for Section procedure was thoroughly discussed and as a result a very clear idea was gained by those present as to the best methods of carrying on Section work.

The various Sections have recently elected their new officers for the coming year and the results of most of these elections were published in the May issue of THE JOURNAL. Photographs of all of these new officers are shown on other pages of the present issue, with the exception of W. M. Newkirk, treasurer of the Pennsylvania Section, and J. S. Clapper, treasurer of the Minneapolis Section, whose photographs were not received in time for publication.

The regular Section meetings are now discontinued for the period of the Summer, but will be taken up with renewed vigor early in September. A number of important meetings were held during May and the early part of June. An account of the proceedings at the joint meeting of the Mid-West Section and the National Gas Engine Association is given in the first part of this issue.

Cleveland Section.—At the May 17 meeting of the Cleveland Section, Robert B. Lea of the Sperry Gyroscope Company, Brooklyn, N. Y., gave a talk on the subject of gyroscopes, using models to demonstrate many of the points discussed. He stated that Mr. Sperry first became interested in gyroscopes as a means of amusing his children, but soon sought ways of applying their pent-up forces to useful purposes. All knowledge of the gyroscope has been shrouded in mathematics for ages.

As a matter of fact, the gyroscope's action can be determined very easily after knowing the two principal laws upon which its operation depends. The first of these two laws is that any body revolving about another body tends to turn so that its axis assumes a position parallel to the axis of the body about which it is revolving. The second is based on Newton's "first law of motion," from which it follows that a particle revolving in a plane tends to stay in that plane, and can be disturbed from its orbit only by the application of force.

In fact, any body that revolves is in effect a gyroscope. The earth is a huge gyroscope. However, the gyroscopic forces of a rotating body do not come into play unless it is allowed to precess, that is, to follow its path or orbit. Speaking of the gyroscopic compass, Mr. Lea stated that one of its chief advantages is that it indicates the true north instead of the magnetic north. When the great masses of metal in the turrets on modern battleships are moved, the magnetic compasses frequently are deflected as much as 6 deg.; in passing under steel bridges the deflection is very noticeable. The gyroscopic compass not only gives the true north reading, but it operates with a force nearly three hundred times greater than that of the magnetic compass. Gyroscopic compasses are not used on airplanes for the reason that their weight is objectionable for such an application. The stabilizer is made of aluminum alloy and weighs 40 lb.

In reply to a question as to whether gyroscopic stabilizers are used on battleplanes, Mr. Lea stated that very few are used at the present time. The fighting aviator must be able to go through all sorts of maneuvers, and a stabilizer would increase the difficulty of manipulating the machine as well as adding to the weight, which is also a very serious consideration.

Detroit Section.—The May meeting, the last of the season of the Section was held on the 24th. Lee Anderson, vice-president of the Hupp Motor Car Corporation, discussed the sales problems of the immediate future. It might be said, he stated, that there are no real sales problems at present. This is the golden age of the engineer, the man who creates. The age of the salesman, however, is coming. Existing factories are being expanded, and when the war ends the outputs of those factories will exceed any production that this country has ever seen. Engineers will be important factors in the ultimate solution of this coming merchandising problem, as they will be called upon to devise the products that the world will need most in peace times. The engineer should therefore study sales problems so that the new productive capacity may be utilized not alone for what has been manufactured in the past but for new things.

This country, according to Mr. Anderson, is negligent in not preparing for industrial activity after the war. Officers of European automobile companies have visited us within the past year to find out what this country will buy in the automotive field after the termination of the war, so that their plants, now devoted exclusively to war work, may be devoted to the kind of production that will be in demand here after the war.

The present selling problem in the automobile industry is not how or where to sell cars, but to whom and in what quantity to allot them. Mr. Anderson referred to the unenviable position of the great majority of automobile dealers in this country. He proposed three rules, based on the following questions, for dealing with this problem.

First: Is the dealer's business a side line or is it his principal source of income? If he is a general storekeeper or capitalist with other sources of income, and has simply invested in the automobile business as a side line, he should be eliminated first.

Second: To what extent is the dealer under consideration dependent upon a particular product? If he is an exclusive dealer for some automobile company, and is eliminated, he must become bankrupt unless he can secure new business connections. If he handles several makes of cars or a large number of accessories, has a large garage business, handles tractors, trucks, etc., then it is logical to cut the passenger-car distribution to him.

Third: How large an organization is at stake? That question might be: How large a distribution center does the dealer represent?

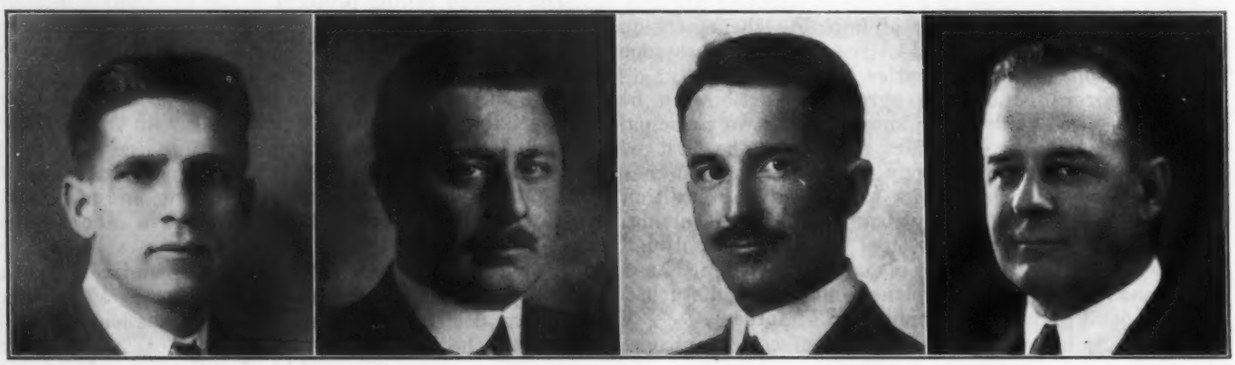
Mr. Anderson gave the following five reasons as the principal ones for the present state of curtailment in the automobile industry: First, railroad transportation. It is not only very difficult to get material into the factories, but it is almost impossible to ship the completed product in freight cars. As a result, drive-aways of a thousand miles are now commonplace. The second factor is labor. There is a natural war demand in the labor market, and in addition the supply is curtailed as a result of the extremely high prices paid for labor. In Detroit, for instance, this seems to result in an average of 12,000 idle men, in spite of the shortage of 20,000 men. The third problem is the shortage of steel. The fourth is

H. R. Corse, Ch'man. David Fergusson, V-Ch. O. M. Burkhardt, Treas. E. T. Larkin, Sec'y.

BUFFALO SECTION

H. H. Newsom, Ch'man. S. G. Thompson, V-Ch. R. S. Begg, Treas. R. E. Clingan, Sec'y.

CLEVELAND SECTION



J. E. Schipper, Ch'man. A. C. Hamilton, V-Ch. D. T. Hastings, Treas. C. F. Van Sicklen, Sec'y.

DETROIT SECTION

Earl A. Bessom, Ch'man. W. S. Reed, V-Ch. G. T. Briggs, Sec'y.-Treas.

INDIANA SECTION

undoubtedly the shortage of coal, and the fifth that of rubber.

A committee of tellers appointed by Acting Chairman Van Sicklen reported that the following officers were elected for the Detroit Section to serve during the coming year: J. Edward Schipper, chairman; A. C. Hamilton, vice-chairman; D. T. Hastings, treasurer; C. F. Van Sicklen, secretary; and R. E. Wells section member of the Nominating Committee of the parent Society.

Metropolitan Section.—The Metropolitan Section held a highly successful meeting on May 20th at which the members of the Council were guests. President Kettering gave one of his usual fascinating talks, on the aircraft situation. Councilor Charles M. Manly and General Manager Clarkson told of the work done at the recent International Aircraft Conference which they had attended in London. Capt. B. C. Crossley described his experiences with the Transport Service of the British Army, dwelling particularly on the methods used in making emergency repairs at the front. He also emphasized the need for standardization of motor trucks in order to help solve the maintenance problem under war conditions.

President Kettering, in his address, reviewed the present aircraft situation and assured the members present at the meeting that the design of the present Liberty aircraft engine is fundamentally correct and that it is now being produced in satisfactory quantity. In connection with his work with experimental fuels he stated that he had demonstrated to his satisfaction that compression pressure is not, as generally believed, related to maximum explosion pressure.

A feature of the evening was the showing of a number of motion picture films from France. These were actual views of manufacture of French airplanes and airplane engines.

Pennsylvania Section Outing

The annual outing of the Pennsylvania Section was held on the 25th of May. In the afternoon nearly 200 members of the Section and their guests proceeded by boat to Hog Island, where they inspected the shipbuilding going on there and visited the immense factories that are a part of the equipment being installed for the use of the Emergency Fleet Corporation. In the evening a dinner was held at the Hotel Adelphia, Philadelphia.

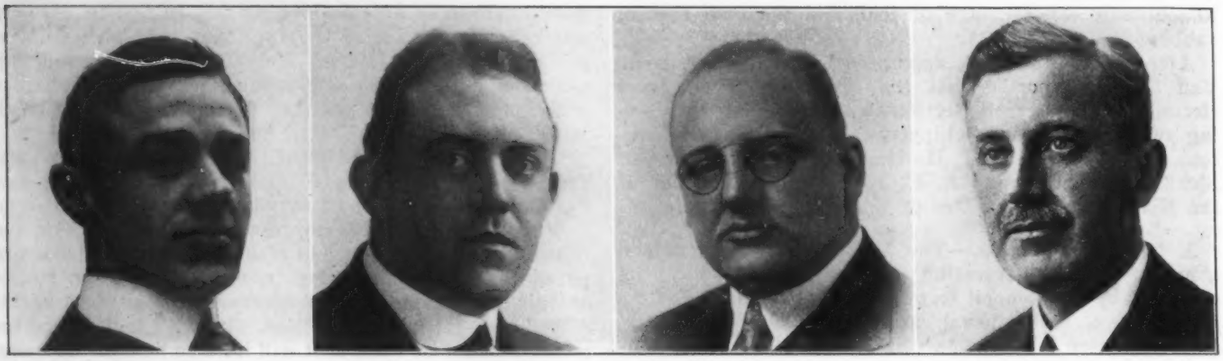
At the dinner the introductory speech was made by Chairman C. A. Musselman, who called on those present to help in securing a five-fold growth of the Pennsylvania Section during the year. He paid tribute to Secretary H. E. Rice for his work in arranging all the details of the outing, and then introduced the Hon. R. O. Moon, former member of Congress from Pennsylvania, as toastmaster of the evening. Mr. Moon first read a letter of regret from Charles M. Schwab, which said that public business at the last moment had prevented his attendance. The next speaker was Harry Tipper, his remarks consisting of an analysis of the labor problem now confronting American industry. In closing, Mr. Tipper called attention to the fact that the subject is not entirely an economic one. He said: "Its principles are philosophic, its processes psychologic, and its results economic, but it cannot possibly be solved by dealing only with economics."

David Ludlum, president of the Autocar Company, who recently returned from France after studying at first hand the motor transport service of the American Army in France, described his impressions of the trip. In Bordeaux, for instance, he had seen the reception park prepared for American motor trucks. The repair station at this park contains a stock room for parts covering 300,000 sq. ft., all on one floor. He also told of the immense amount of work that will have to be done by motor transports, at the same time paying tribute to the work done by the American railway engineers in building new steam roads.

The next speaker turned out to be one of the best entertainment features of the evening, although for a time most of those in attendance took him for what he was introduced to be, an Italian, Count Giuseppe Spatola. The "count" told of some of the experiences in the aircraft work in this country, but after a reference to profiteering in this country he was called to order by a prominent member of the Society, and it then developed that instead of being a count, he was Tom Daly, a well-known humorist and poet of Philadelphia.

H. L. Horning was then introduced as chief of the Automotive Products Section of the War Industries Board and he discussed the Liberty aircraft engine and Liberty motor truck. It requires for the former, he said, only ten working hours to make a cylinder, whereas for the Rolls-Royce cylinder 150 working hours are required. He emphasized the fact that thousands of Liberty engines are wanted by the Allies as rapidly as they can be produced. In closing, he said that it should be the pride of all the members of the Society that the greatest aeronautic engine in the world and the most efficient war trucks are now in production in this country.

The final speech of the meeting was made by Wm. B. Stout, technical advisor to the Aircraft Board. Mr. Stout called attention to the fact that the aircraft program had to be started from the ground up in this country, since no one here had ever made the machines in quantity. He quoted a British flyer, who, after seeing what the Liberty engine would do, said that he had never been up behind an engine, foreign or American—French, Italian or English—that compares with the Liberty. A number of questions were asked Mr. Stout at the conclusion of his more formal remarks. In answering them he said that five German planes were now being destroyed for each French plane brought down. The last German giant plane that raided London carried five bombs weighing 600 lb. each. At present, 2 and 3-in. guns are being used for aircraft work. The great advantage of the German plane equipped with the 160-hp. Mercedes engine is in its diving ability, thus assuring a marked stragetic advantage for the German flyer.



C. F. Scott, Ch'man. H. G. McComb, V-Ch. A. C. Bergmann, Treas. Reuben Allerton, Sec'y.
METROPOLITAN SECTION

H. C. Buffington, Ch'man. J. L. Mowry, V-Ch. C. T. Stevens, Sec'y.
MINNEAPOLIS SECTION

C. A. Musselman, Ch'man. J. W. Watson, V-Ch. H. E. Rice, Sec'y.
PENNSYLVANIA SECTION

G. W. Smith, Ch'man. C. S. Whitney, V-Ch. L. R. Smith, Treas. D. S. Hatch, Sec'y.
MID-WEST SECTION

Possible Automotive Adaptations of Heavy-Oil Engines

By P. L. Scott* (*Non-Member*)

Semi-Annual Meeting Paper *Illustrated with* Photographs and Charts

It is the purpose of this paper to point out a means of meeting the ever-increasing demand for automotive power by more extended and more economic use of hydrocarbon oils and to discuss briefly the mechanical and thermal problems introduced by this development. There has been encouraging progress in this work, some abroad and some, but regrettably slight, in this country. The problem will, therefore, be considered here largely in the abstract, the probable lines of development being indicated.

Power demands, automotive power included, are compelling us to give attention to the great need of better utilization of our natural resources. Conditions brought about by the abnormal requirements of the war and the greatly extended use of automobiles have made us audit an account of fuel credits and debits, and the balance sheet is a distinct shock to our prevailing complacency.

Fuel Determines Design

The fuel supply is now determining the type of engine for automotive purposes. Our crude-oil production in 1917 was 29 per cent greater than in 1916, yet it failed by far to meet the increased demand for gasoline. This is clearly shown by the following figures as given in Bureau of Mines Reports for 1916 and 1917. From June 30 to Sept. 30, 1917 (an active period for automotive power) the demands for gasoline necessitated the withdrawal of 77,217,782 gallons from our reserve stock. In the same period the kerosene reserve stock was increased by almost an equal amount, 68,493,824 gallons. Evidently we should have been able to use kerosene at the same rate as gasoline. Next to gasoline, kerosene is best suited for high-speed internal combustion engines; but the kerosene has not been used because we have no engines that can burn it successfully.

Our daily average output of gasoline is 6,763,457 gallons, and of kerosene it is 4,333,764 gallons (Bureau of Mines). From kerosene we have a source of power, which, gallon for gallon, is 60 per cent greater than that from gasoline. Further, and a fact that makes more impression even at the present time, gasoline retails at from 21 to 33 cents per gallon and kerosene from 7 to 17 cents per gallon, according to grade and quality. So not only from broad economic reasons, but also for the benefit of our own pockets should we develop kerosene and low-grade oil-burning engines.

If all our bituminous coal were to be distilled in by-product ovens and the light oils thus obtained used for automotive purposes, 753,779,523 gallons of fuel per year would be available, a supply upon which, up to the present time, we have not drawn upon at all for the purposes proposed. Without any change in our method of using coal, we can now obtain from coal 117,641,233 gallons per year of oil suitable for automotive engines. But in addition to these comparatively light oils, vast quantities of the heavier distillates, which will eventually be used, are so far only a potential power supply.

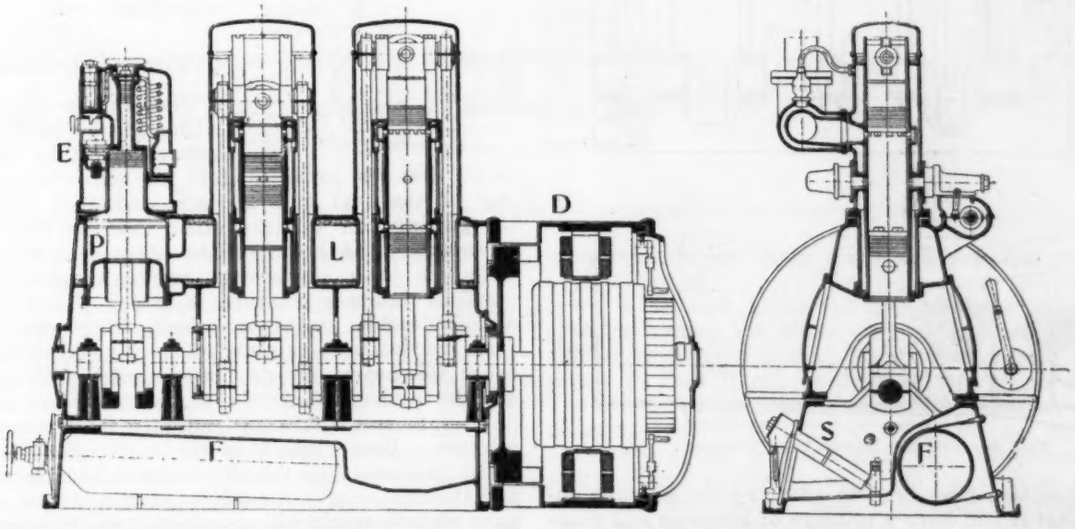


Fig. 1—Small Double-Piston Two-Stroke Cycle Oil Engine, Direct-Coupled to an Electric Generator, Made by Allgemeine Elektricitaets Gesellschaft

Heavier Oils as Gasoline-Engine Fuels

The first high-speed internal combustion engine was the result of a demand for a powerplant of less weight and size, not of a demand for a powerplant more economical in its use of fuel. In the early days of the art difficulties in the operation of such engines demanded the use of a very volatile fuel, and even now an oil of good

*Engineer, Super-Diesel Tractor Corporation.

volatility is required for types of these engines using carbureters. The tremendously increased demand for gasoline for automotive purposes has led to efforts to increase the supply of fuels for the common forms of internal combustion engines. Mixture of gasoline and kerosene, low-grade gasoline, benzol, alcohol and pure kerosene have been suggested. So far little effort has been expended in the design of engines, either specifically for the use of heavier fuels—which differ strikingly in their characteristics from gasoline—or for the more economic use of fuel in general. Such attempts as have been made

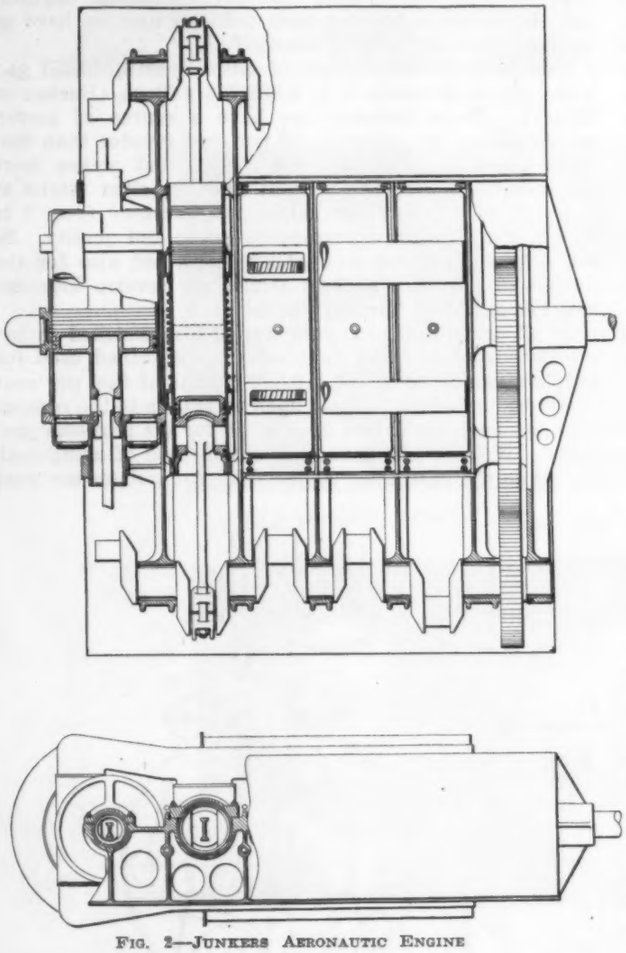
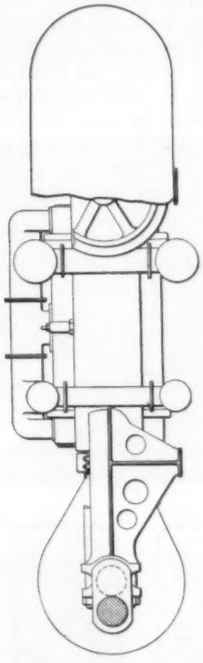


FIG. 2—JUNKERS AERONAUTIC ENGINE

in this direction have been in adapting the gasoline engine so that it will burn a mixture of kerosene and gasoline, or kerosene alone.

A survey of the results so far attained leads to the conclusion that the right procedure has not been followed. The present type of gasoline engine does not burn with success (and by success we mean good combustion at all loads) kerosene, or even a mixture of gasoline and kerosene in which the proportion of kerosene is high; nor do many of these engines burn kerosene well even at full load. This is because kerosene will not volatilize at ordinary temperatures and pressures, and low-grade gasoline, now very common, volatilizes only partly under normal conditions. Volatilization is essential if the oil is to be mixed with the air by any of the present forms of carbureter. The vaporization of the heavier oils can be assisted by heating, but even then is not sufficient to produce a complete and homogeneous mixture of oil vapor and air. If gasoline and kerosene are placed side by side in two receptacles exposed to the air, the gasoline will disappear by evaporation long before the kerosene. Attempts to apply heat frequently fail of their object because the heat does not sufficiently aid in volatilizing the oils, and, more important, because it decreases the weight of oxygen drawn into the cylinder of the engine. The amount of power is dependent upon the amount of fuel that can be burned, and the amount of fuel that can be burned is dependent in turn upon the amount of oxygen that can be drawn into the cylinder at each charging stroke. Heating of the air decreases its density, consequently reduces the amount of oxygen and correspondingly cuts down the power output.



Many have expressed the opinion that the next logical step to meet the fuel situation is the design of an engine especially suited to the burning of kerosene or of the lower petroleum distillates and the lighter and possibly "middle oils" resulting from the by-product distillation of coal, and not an attempt to adapt engines designed for a volatile oil to the use of relatively non-volatile oils.

BURNING LOW-GRADE FUELS

The author believes that with a heavy fuel engine some means other than carburetion must first be provided for the most intimate mixing of the fuel and the air, and that some means of igniting this mixture other than an electric spark is necessary. A heavy oil cannot be successfully mixed with air in a carbureter, and a spark cannot successfully ignite a mixture in which the oil is not to a considerable extent vaporized. Carbureters fail to form an intimate mixture of heavy oils with air because the heavy oils do not volatilize sufficiently well, and the mechanical division of the oil secured in the carbureter is never sufficiently fine to form a combustible mixture. Heat applied to the carbureter in order to assist in volatilizing the oil results in heating of the air, and thereby reduces the output of the engine. An ordinary electric spark will usually fail to ignite a mixture of heavy oil and air because the source of heat is too localized and the flame propagation is much slower than in the case of a readily volatilized vapor mixed with air. Further, as the compression used is increased the resistance to passage of the spark is decreased, owing to the increased density of the air.

Working of Diesel Engines

The alternative is to use purely mechanical means for dividing and mixing the oil with the charge of air. In the Diesel engine this mixing is successfully accomplished by using highly compressed air, delivered by a compressor attached either to the engine or driven separately, to blow the oil into the cylinder at the moment when com-

bustion is desired. The pressure in the cylinder is from 400 to 700 lb. per sq. in. and that of the injection of air is from 50 to 100 per cent higher. The proper quantity of oil for one cycle is delivered to the fuel valve during each stroke and at the right moment is forced by this air pressure through passages and holes of various shapes and sizes into the cylinder. A certain amount of the air escapes from the valve with the oil.

This method has one great advantage. The oil and the air, under a pressure considerably higher than that in the cylinder, become thoroughly mixed during the passage through the valve, so that when the pressure is suddenly decreased, say from 800 lb. in the valve to 500 lb. in the cylinder, the oil, already well divided, is subjected to a violent explosive action that tears the small drops apart and produces a finer division, thus rendering the fuel readily combustile. Further, combustion is readily started because each particle of fuel is provided initially with a small amount of air in close contact with it.

This system has several disadvantages. An air compressor is an unwelcome piece of apparatus, doubly so for high pressures and for high speeds; and is not to be thought of for speeds required for automotive engines. When the pressure is suddenly decreased on the entrance of the injection air into the cylinder, the expansion causes a decided refrigerating action upon this air, which is in closest contact with the oil. This action will actually prevent combustion when too much air escapes through the valve. From 5 to 10 per cent of the indicated horsepower is required for the operation of the air compressor. Therefore, although producing an excellent spray, air injection cannot be considered for high-speed engines required in most automotive applications.

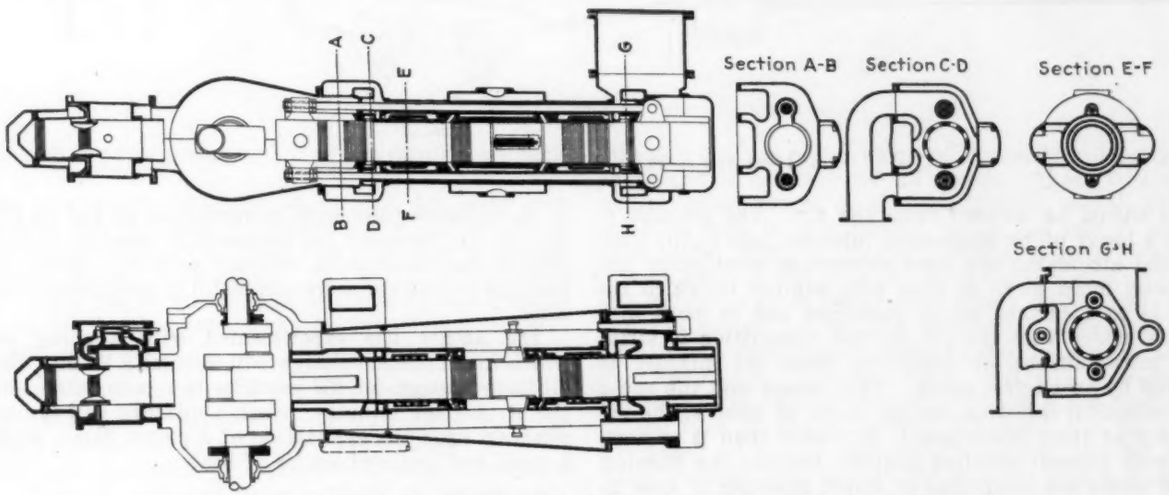


FIG. 3—OIL ENGINE OF TWO-CYLINDER TANDEM CONSTRUCTION FOR FARM TRACTORS

Merits of Direct Injection

Surface ignition engines, at least the smaller sizes, have no air compressor, but inject the oil directly under pressure ranging from 1000 to 3000 lb. or more per square inch. In nearly all designs the oil is forced through an extremely small hole, a few thousandths of an inch in diameter. This gives a fairly good spray, but not one so finely divided that the fuel burns when brought into contact with air at temperatures resulting from the compression pressures used. Further, such sprays are subject to "dripping," that is, the formation of drops of appreciable size before or after injection, or often in the spray itself. This causes excessive carbonization and poor combustion. Therefore, hot surfaces are introduced into the cylinder and the oil allowed to impinge upon or pass near these surfaces. This causes a partial distillation of the oil and furnishes the additional heat necessary for combustion. These conditions tend toward operation on the Otto cycle and the compression pressures, therefore, are kept relatively low to avoid excessive end pressures.

The "direct-injection" system has many merits. With it the air compressor is eliminated, thereby doing away with an expensive and troublesome piece of apparatus and saving 5 to 10 per cent of the indicated horsepower. This saving is net because a high-pressure oil-pump is required whether there is an air compressor or not. The system eliminates the refrigerating action of the compressed air. So far it has had the serious drawback that the fuel spray produced does not burn nearly so well as the "air injection" spray, but in this respect some real improvements are being made and practical success is being obtained.

We must work along the line of direct injection in order to develop the heavy oil burning engine for automotive purposes. Enough progress has been made to assure us that it can be done without great difficulty. The author has observed a successful test of an oil pump pumping benzine at 450 atm. (6390 lb. per sq. in.) at about 800 r.p.m. A pump more recently developed has operated well at 7000 lb. and 1150 r.p.m. High pressure in the oil pump at high speed is an essential requirement for successful direct injection.

Assuming that we can succeed in this mechanical mixing of oil and air, we must next devise a means for igniting the mixture. This can be accomplished either by compressing the air to such an extent that the temperature attained will cause ignition, or by permitting parts of the combustion chamber to reach such a temperature that action similar to that in surface ignition engines occurs. The two methods may be combined, in which case the results are the best. If hot surfaces are used, care must be taken not to allow the incoming air to flow over them, since this will have the same disadvantages as heating the air in the carbureter, namely, reducing its density. Most of the heat necessary under these condi-

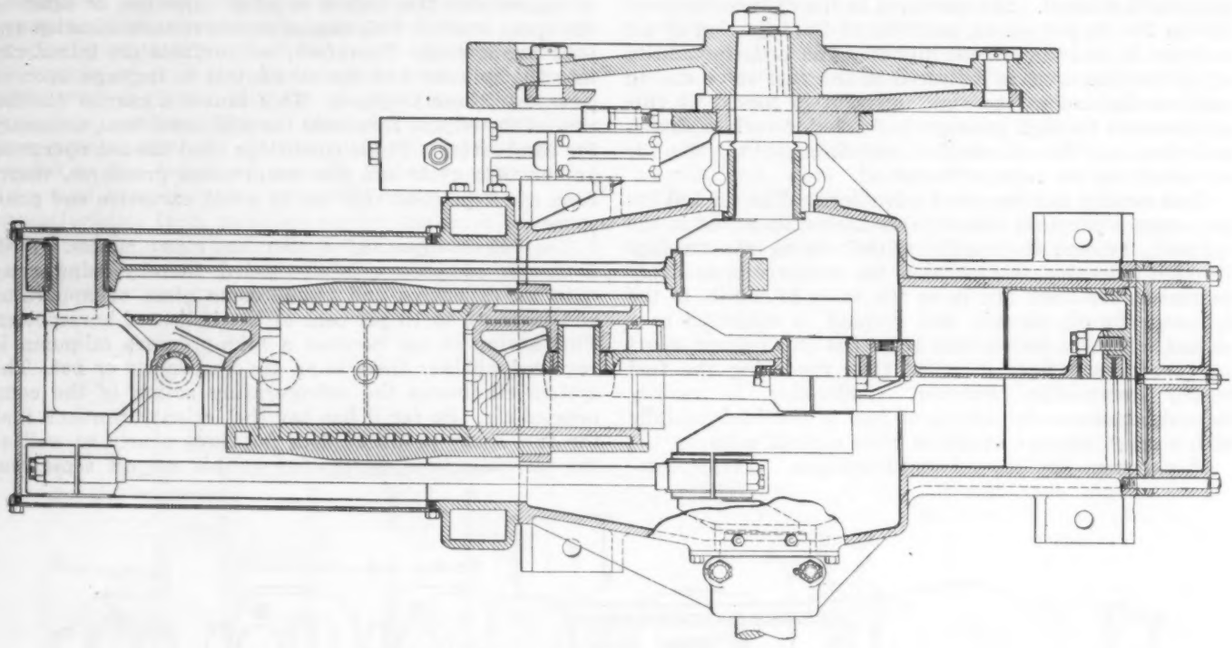


FIG. 4—SECTIONAL PLAN VIEW OF INJECTION OIL ENGINE

tions should be secured from the air. The attempt to burn a heavy oil by mechanical injection into highly compressed air makes the time element of combustion important; much more so than with engines in which the fuel is to a certain extent vaporized and is more intimately mixed with the air, so that combustion is virtually instantaneous, or explosive, when the mixture is ignited by an electric spark. This means that the speed of mechanical injection engines must, at least at the beginning of their development, be slower than is customary with present gasoline engines, because the burning of oil under the conditions of direct injection is slow as compared to the burning of gasoline vapor in air.

Explosive and Combustion Types

It is well to speak here of the distinction between the explosion and the combustion engine, as engines burning heavy oils are essentially of the combustion and not of the explosion type. All engines intended to burn the lighter hydrocarbons are, from the nature of the fuel, most easily designed to operate on the Otto cycle. The fuel volatilizes readily and can be drawn into the cylinder with the air and compressed, provided the compression pressure is not too high, and the mixture then ignited. The rise in pressure due to the chemical reaction is almost instantaneous and is the so-called constant volume, or explosive, combustion.

The heavier oils, however, will not mix so intimately with air, and the heat of the air must be relied upon to a great extent to aid in the union of the fuel and the oxygen; consequently combustion is never so rapid, but approaches the constant pressure conditions found in the Diesel cycle. A mechanical condition prohibiting the use of the Otto cycle for heavy oil engines of the proposed type is that the comparatively high compression pressure necessary would produce prohibitive explosion pressures.

The development of direct injection in large engines has conclusively proved that heavy oils, even residues, can be sufficiently finely atomized by mechanical means to burn successfully with compressions as low as 250 lb. per sq. in., provided the combustion space is allowed to remain warmer than in ordinary practice. Direct injection has proved far more successful in small than in large sizes.

The author has experimented with a spray nozzle which in its present design will atomize a 28-deg. Baumè oil finely enough for the particles to remain suspended in the air for ten minutes. Such a mixture will ignite explosively upon the application of a match flame, which is a small and localized source of heat.

Differences in Design

Bearing the foregoing considerations in mind, we see that the design of injection engines will differ radically from that of the usual type of gasoline engine.

In the first place, the engines will be of considerably slower rotative speed than is possible with gasoline engines. With better design we can secure higher speeds, but satisfactory operation at 1000 r.p.m. would now be considered a creditable attainment. We must, therefore, for the present make up our minds to use slower speeds. The slower speed engine will naturally be larger and heavier than the gasoline engine to which we are accustomed, particularly when operating on the four-stroke cycle, but we must remember that the first gasoline engines were truly clumsy affairs when compared with present designs. The engines will not need to be much heavier for strength to carry the high compressions because the maximum pressure will not be much greater, although the mean effective pressures will be higher. But the cylinder and piston design will be more difficult, since the mean temperatures will be considerably higher. Because of the slower speed and probable increase in size and weight there will doubtless be a reversion at first to engines with larger and fewer cylinders. It will probably be more economical to build two-cylinder than four-cylinder engines of this type. Further, a small cylinder for an engine of this type requires such a small quantity

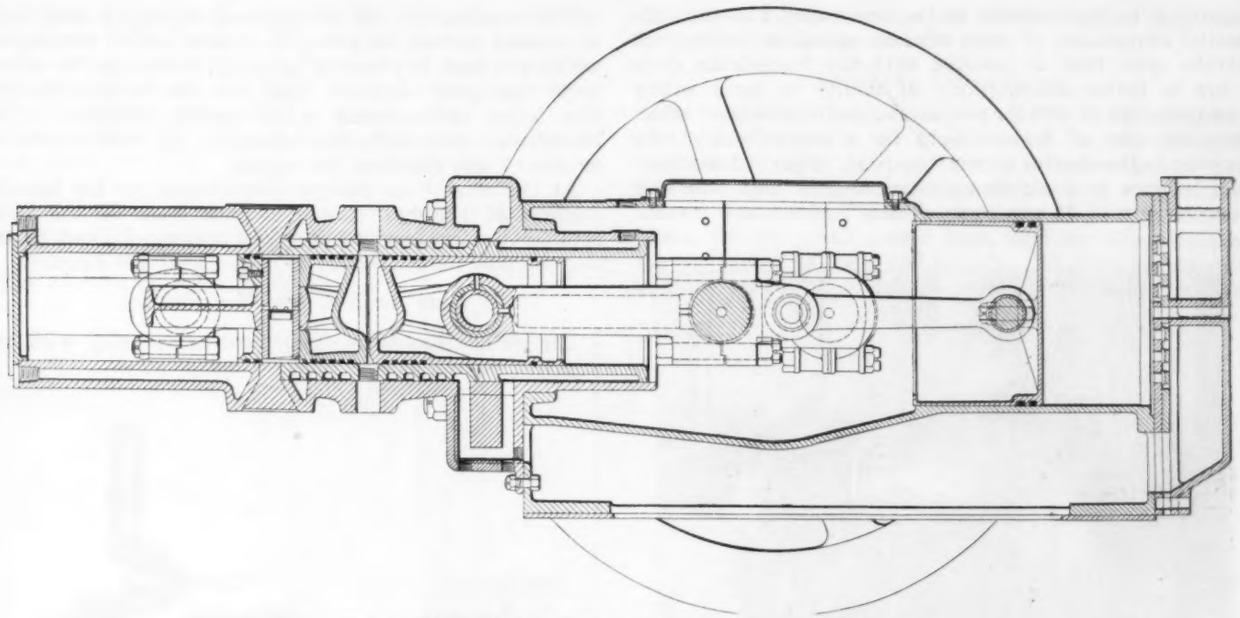


FIG. 5—SECTIONAL SIDE ELEVATION OF INJECTION OIL ENGINE

of oil that the fuel pump design and governing are difficult.

The only means available at present for effectively combating the tendency to increased size and weight is in the employment of the two-stroke cycle, and this cycle, therefore, should be developed. The author is convinced that success can be obtained in this way by the employment of the double-piston principle, details of which will be discussed later.

ADVANTAGES OF HEAVY OIL ENGINES

The general advantages of heavy-oil engines for automotive purposes can be summed up as follows:

They will be simple in construction, since the spark-plug, magneto and carbureter will be dispensed with, these being replaced by fuel pump and valve, less complicated and more reliable elements.

They will burn cheaper fuels and will have a lower fuel consumption than the present gasoline engines.

The consumption of gasoline engines varies from 0.5 to 1.5 lb. per b.hp. per hr. or higher depending upon such factors as the compression ratio, quality of carburetion and load. If we take the average gasoline consumption as 1 lb. (airplane engines not considered) and the cost of gasoline as 25 cents per gallon, the fuel cost is 3½ cents per b.hp. per hr. High-speed Diesel engines have burned from 0.45 to 0.7 lb. per b.hp. hr. of fuel. Six-tenths of a pound may be taken as an average. At a fuel cost of 7 cents per gallon this is equivalent to 0.6 cents per b.hp. hr. for fuel to operate such engine, or about one-sixth that for the gasoline engine. On this basis it would seem to be a necessary step in the conservation of our natural resources to encourage the development of the heavy-fuel type of engine.

Injection engines will be as flexible or more so than gasoline engines, and more economical at reduced load and speed, since the high compressions advisable for normal speed will insure compressions at low speed always well above the burning point of the oil, and since the trouble arising from changes in the efficiency of the carbureter at varying speed due to the varying suction will be entirely eliminated. The characteristic of the fuel injection depends on the shape of the cam for driving the pump and is constant for all speeds. There is a well-authenticated report of a single-cylinder engine of the injection type in this country which has run at speeds from 160 to 1600 r.p.m., a truly creditable performance.

Such engines will have the disadvantage of larger size and weight in their initial development stages, and cylinder and piston trouble and lubrication difficulties will probably be experienced, owing to the much more severe heat conditions. Further, some time will undoubtedly be required to educate the public to such a radical change in the type of motive power. However, the design of the heavy oil engine represents a simpler and far more exact problem than that of the gasoline engine, and this should make rapid development possible.

OPERATION OF HVID TYPE

The development of heavy fuel engines is not a new undertaking, and it is a pleasure to note the progress made up to the present time. In this country many small engines are operating with compression pressures of from 100 to 450 lb., and injecting the fuel directly. Notable among these is the Hvid design, using a most ingenious device for injecting the fuel. The oil is permitted to flow into a small receptacle in the cylinder during the suction stroke. This receptacle is hot and is perforated with a few small holes. A portion of the oil is vaporized by the heat of the receptacle and ignited by the heat of compression. The explosion that results in the receptacle drives the remainder of the oil from the receptacle into the cylinder through the small perforations. It is thus sufficiently atomized to burn.

The system has one great disadvantage in that the rate of injection of the oil cannot be controlled. Accurate control of the rate of injection is essential to the ultimate success of such engines. These engines can operate only on the four-stroke cycle, and therefore are at a disadvantage in point of weight and size to a greater extent than are engines operating on the two-stroke cycle.

A specific development of a double-piston two-stroke cycle engine with which the author is personally ac-

quainted is that known as the Junkers. This has the initial advantages of more efficient operation on the two-stroke cycle than is possible with the four-stroke cycle (due to better scavenging), of ability to carry safely compressions of 700 lb. per sq. in., and also higher mean temperatures, of lower height for a given total stroke (owing to the shorter connecting-rod), of perfect mechanical balance in a single cylinder, and of high overload capacity, up to 75 per cent. These features are invaluable in the problem of keeping weight and size down, in increasing flexibility, and in securing reliable operation at high temperatures.

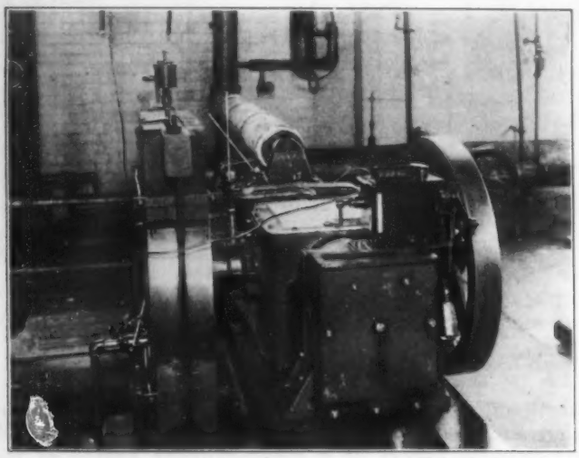


FIG. 6—FLYWHEEL END OF ENGINE SHOWN IN FIGS. 4 AND 5

In 1914 the Allgemeine Elektricitaets Gesellschaft had developed small units of this type, direct coupled to electric generators, which ran fairly successfully at 750 r.p.m., showing that oil could be injected and burned at that speed. One of these is shown in Fig. 1.

These engines used "air injection," however, but they served as a basis for the construction of an automobile engine with direct injection, which was officially reported to have been successful in October, 1915, and further, for the development of airplane engines. The first experimental engine of the last mentioned type was seen by the author in the year 1916 in Germany.

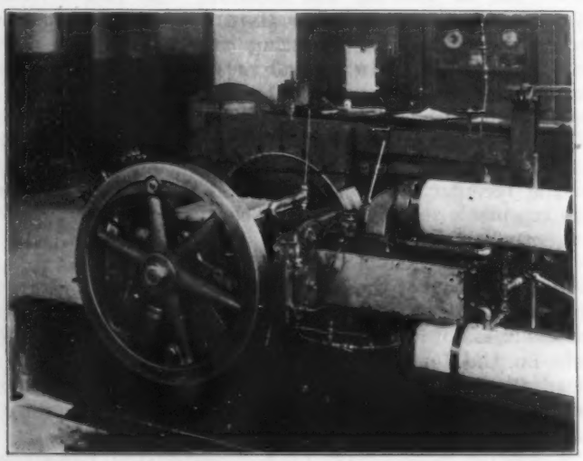


FIG. 7—ANOTHER VIEW OF ENGINE SHOWN IN FIG. 6

The construction of an airplane engine of this type is unusual in that the power is transmitted to two shafts which are kept in phase by gearing; power can be taken from this gear train or from the shafts individually. The latter arrangement is, of course, the best. The use of two crankshafts eliminates the side rods otherwise necessary and shortens the engine.

At the same time designs were drawn up for tractor engines of 140 hp. These engines were of the two-cylinder tandem construction, and measured about 10 ft. over all, but were intended to run at only 500 r.p.m.

Data for New Injection Engine

The author has been experimenting recently with an injection engine of this construction.

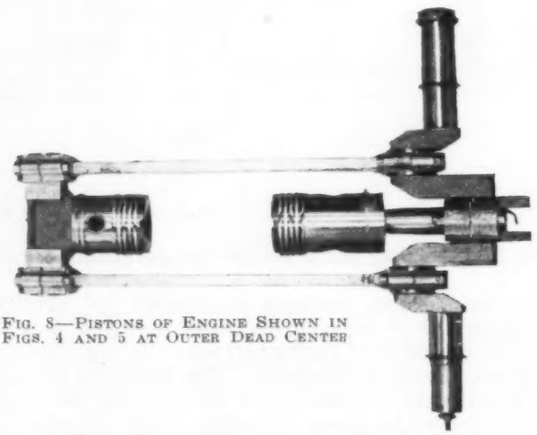


FIG. 8—PISTONS OF ENGINE SHOWN IN FIGS. 4 AND 5 AT OUTER DEAD CENTER

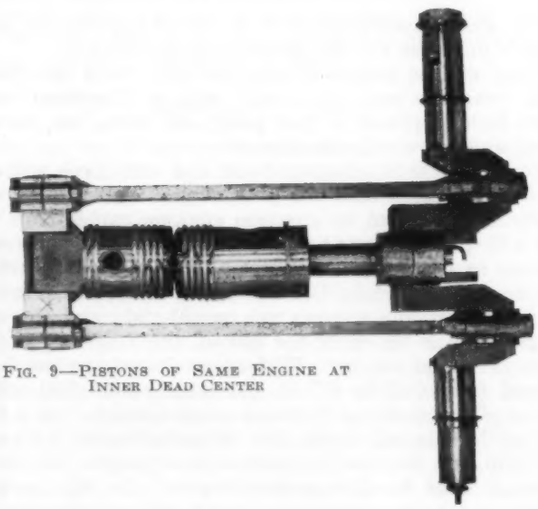


FIG. 9—PISTONS OF SAME ENGINE AT INNER DEAD CENTER

The general arrangement is shown by the Figs. 4 to 9 inclusive.

This engine was designed along lines which were known to have been proved successful in other engines. The next step in the development is shown in Fig. 10.

From data already at hand, combustion at high speed in such a construction is known to be possible.

The present engine has but a single cylinder, 5-in. bore, 10-in. stroke, and is expected to develop 40 hp. at

700 r.p.m. It is 55 in. over all and 22 in. wide over the crankcase, or 31 in. over flywheel and driving gear.

By comparing the figures showing the piston at inner and outer dead center (Figs. 8 and 9) the long stroke compared to the short crank is readily noted.

The vertical construction shown has two cylinders of 4-in. bore and 6-in. stroke, and will develop 35 hp. at 800 r.p.m., or 44 hp. at 1000 r.p.m.

These figures are for compressions of 700 lb. per sq. in. and 115 lb. per sq. in. brake mean effective pressures.

The vertical-type construction is 28 in. long, 24 in. high and 10 in. through the engine.

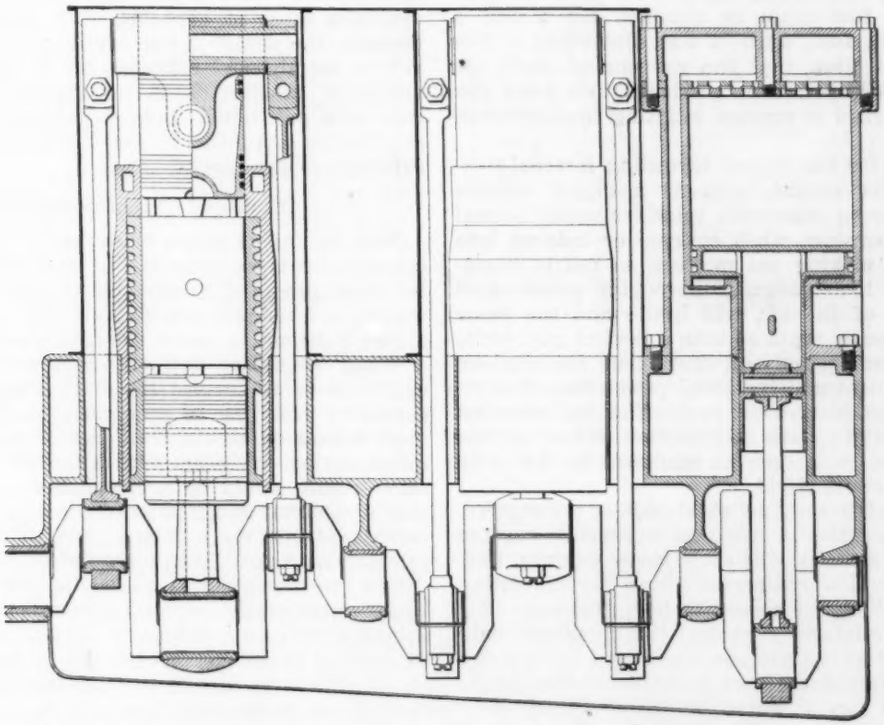


FIG. 10—VERTICAL OIL INJECTION ENGINE, A LATER DEVELOPMENT OF THE ENGINE SHOWN IN FIGS. 4 AND 5

Both these engines can be built to carry 50 per cent overload.

The present engine has, at the time of this writing, been on the test block a week, and has performed as follows: Starting on first trial on fuel oil, 600 r.p.m. on fuel oil and 700 r.p.m. on kerosene, with ability to go faster, 13 hp. at 400 r.p.m., and an hour's continuous run without trouble.

These were, of course, only elementary trials, and were all of short duration except the hour's run, but they hold forth great encouragement.

AUTHOR'S CONCLUSION

The necessity of developing the heavy oil-burning engine for automotive purposes cannot be too strongly emphasized. The demands for automotive power for the farm, for freight carrying and trucking of all kinds, for the automobile for both passenger and business purposes, for the small power boat, and for the airplane, are increasing by leaps and bounds. We have not enough suitable gasoline to supply even our present requirements, and we have almost no engines capable of successfully burning heavier distillates. The supply of such heavier distillates is comparatively vast, and the heavy oil engine will use this supply much more economically than the gasoline engine uses gasoline. Self-propelled vehicles have become essential to industrial development. If we would maintain and increase our industrial vitality, particularly under the present tremendous stress, let us bend our efforts to this problem.

A Type of Heavy-Oil Engine for Automotive Purposes

By C. E. SARGENT* (*Member of the Society*)

SEMI-ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND CHARTS

WHEN the automobile engine came into being an excellent fuel could be obtained for a cent a quart. In fact, until it was discovered, a few years before that time, that the gas engine could use for fuel the volatile petroleum products, they were distilled away or burned to prevent vitiating the surrounding air.

A perfect fuel for the typical throttling internal-combustion automotive engine, such as a highly volatile gasoline or petroleum ether, will volatilize under normal atmospheric temperature when sprayed or induced into a stream of air, making the mixture so nearly homogeneous that the hydrocarbons, thoroughly commingled with the oxygen of the air, will ignite and the flame propagation will be as rapid as with a perfect gas, while the products of combustion will contain no free carbon. With the development and increased production of automotive engines, the demand for such a fuel has exceeded the supply, necessitating the introduction of less volatile products, and even with such an adulteration the price has increased six hundredfold.

With large quantities of fuel obtainable at a low price, there was little incentive to construct automobile engines of high efficiency, and, like the early steam engines, they were designed for low compression and for throttling control, both of which are conducive to inefficiency.

Throttling the mixture to control the speed not only causes loss in fuel at the average speed by lowering the compression, but introduces back pressure on the piston, which is overcome only at the expenditure of many heat units.

Gasoline Engines Not Adapted for Heavy Fuel

In order to volatilize properly and use commercially present-day fuel the temperature of the mixture must be raised before compression, and as a result the maximum engine power is decreased, because fewer heat units are induced. As fuel becomes less volatile, more sensible heat will have to be supplied to obtain satisfactory combustion and still less power per unit of piston displacement will be developed.

The burning of kerosene in gasoline engines has been a commercial failure. Gasoline truck and tractor engines using kerosene for fuel require replacements and repairs and so much more lubricating oil that maintenance costs more than offset the fuel saving.

Heating the air and fuel assists in gasification, but the power obtained from an engine varies inversely as the temperature of the induced charge; therefore, to maintain equal power output the size of engine must be increased as the air is heated, in order to get the same horsepower output, but increasing the piston displacement requires more throttling for light loads, and thereby further decreases the average thermal efficiency.

Since we cannot expect gasoline engines to operate satisfactorily with a fuel the characteristics of which approach those of kerosene, why should we consent to decrease the power of our engines and at the same time reduce the thermal efficiency or the miles obtained per gallon of gasoline, when an engine properly designed will burn any liquid fuel, give more power per gallon, and enable a vehicle to travel further with the same expenditure for fuel?

Constant Compression Favored

Such an engine as the above would be of the constant-compression type, compressing pure cold air to a predetermined pressure irrespective of the load, and raising the air to a temperature at the end of every compression stroke sufficient to ignite the fuel when it is introduced.

When we realize that the compression in a gasoline engine must not exceed the critical pressure (and temperature) resulting in premature ignition, and that we must depend on an elaborate electric system to start the inflammation—although with a slightly longer piston the same result would be accomplished—it is not strange that a constant compression engine in which the fuel is introduced into the extremely hot air after compression promises such possibilities in automotive applications.

In a constant compression engine there is *no* air throttling, consequently *no* back pressure or braking effect during part loads. There is *no* loss of power through a reduction of volumetric efficiency by heating the induced air. There is *no* loss in thermal efficiency due to reduction of the compression pressure during part (or average) load at which an automobile engine normally runs. Even when both types are developing full load the compression in the constant compression is about eight times that in the throttling type, and the thermal efficiency of the former is higher.

In a throttling engine the sudden rise in pressure due to premature or self-ignition, which causes the "ping" in automobile engines, may equal or exceed the compression in some constant-compression types. Therefore, the weight and strength of the working parts in the latter need not greatly exceed those of the gasoline engine in general use.

Relative Fuel Consumption

The fuel-consumption curves, Fig. 1, in which *A B* shows the average fuel consumed by a typical throttling engine using gasoline, and *C D* the fuel-consumption curve of engines of the constant-compression type, at once make evident the desirability of using the constant compression engine in the automotive field, even if no complicated and delicate accessories were eliminated.

Fig. 2 is an ideal card for an engine of this type, in which the fuel injection is so timed that the pressure increases at the same rate at which the volume of burning mixture is increased by the moving piston, thus making the combustion line *E F* horizontal. The line *F G* is a

*Chief Engineer, Lyons-Atlas Company.

mean between isothermal and adiabatic expansion. Such a diagram indicates a possible thermal efficiency of nearly 50 per cent, and if the mechanical efficiency were 100 per cent a horsepower hour would be developed on about one-quarter pound of fuel.

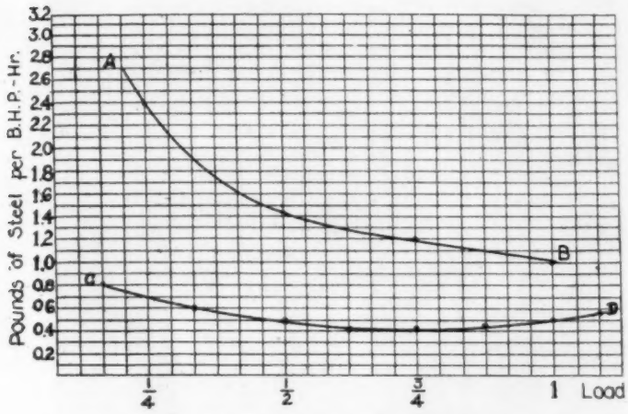


FIG. 1—FUEL CONSUMPTION CURVES
(AB) Typical Throttling Engine, (CD) Constant-Compression Atlas-Diesel Engine

In order to secure an ideal diagram such as that in Fig. 2 the fuel injection would have to be perfectly timed and the fuel itself delivered to the combustion space by air having practically twice the pressure of compression, or approximately 1100 lb. per sq. in.

Air compressors, either direct connected or independently driven, are required to provide the injection air, and if this be used the power required to drive such compressors, the heat and friction losses due to handling the compressed air, and the mechanical friction in the engine itself, bring the net fuel consumption per hour down to from 0.45 to 0.50 lb. per b.hp. hr., a figure much lower than that for the average type of gasoline engine running under the same load.

Engines such as that shown in Fig. 3 are suitable for stationary or marine work, and are believed to be the

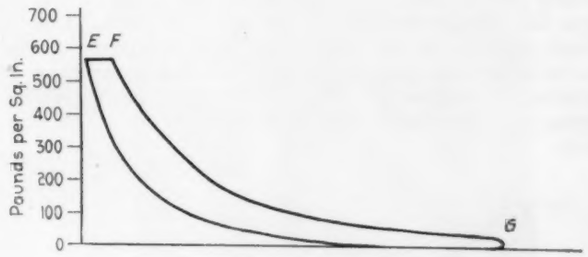


FIG. 2—IDEAL INDICATOR CARD FOR ENGINE OF THE CONSTANT-COMPRESSION TYPE
Full Load M.E.P. 98.5 Lb. per Sq. In.

most efficient prime mover extant. In large sizes they have no superior, on an efficiency basis, and may never be superseded by an engine of other types. However, on account of the difficulty of compressing and carrying air under such high pressure and of providing pumps

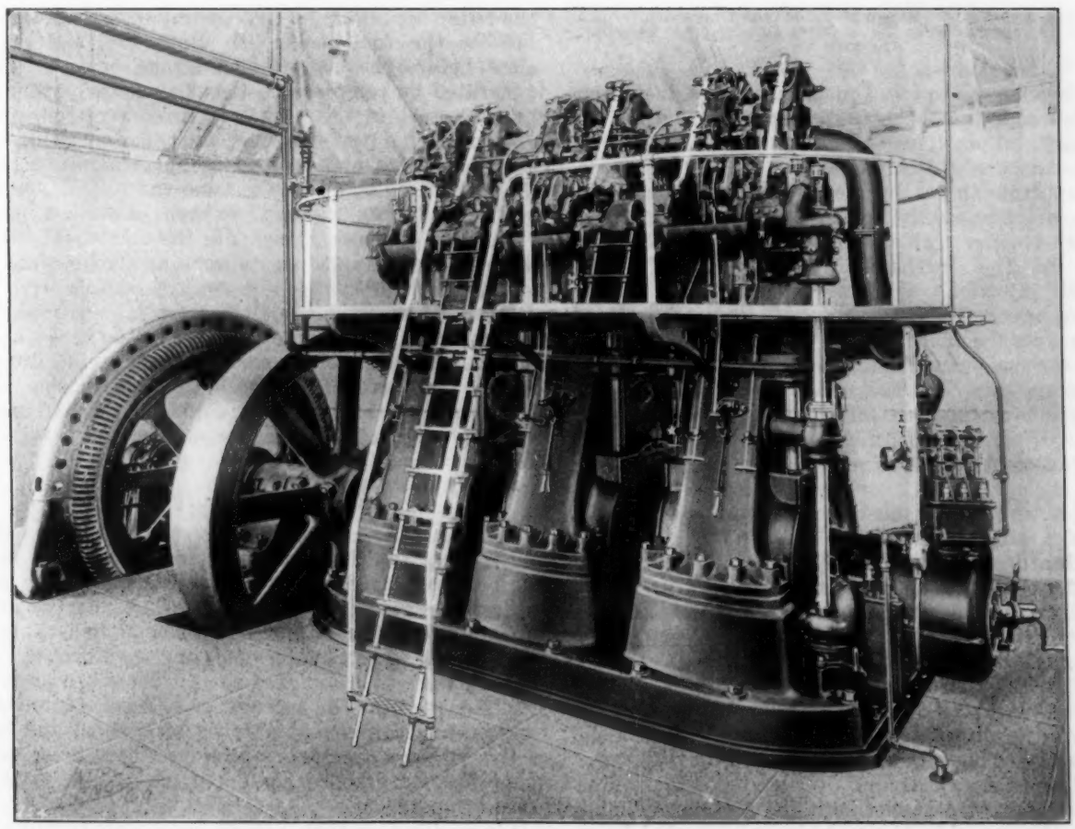


FIG. 3—TRIPLE-CYLINDER 450-500 B.HP. LYONS-ATLAS DIESEL ENGINE, VERTICAL, FOUR-STROKE CYCLE TYPE, DIRECT-CONNECTED TO 375 KW. ALTERNATOR

that will measure and deliver almost infinitesimal globules of fuel to the combustion chamber, portable engines of this type are probably impracticable in small multi-cylinder units, such as are usually required in automotive applications.

Gravity Feed for Fuel

In order to eliminate the complicated mechanism indigenous to this type of heavy oil engine a method has been developed of sucking fuel during the induction stroke through a needle valve into a pocket separated from the main combustion chamber. While not absolutely perfect, this method is simple, and gives commercially successful results. Diagrams from such an engine (Figs. 4 and 5) have the characteristics of the ideal diagram, Fig. 2, except that the firing line varies from stroke to stroke, giving a variable ignition pressure. The percentage of variation is no greater than in the spark-fired gasoline engine, and the mean effective pressure is as nearly constant.

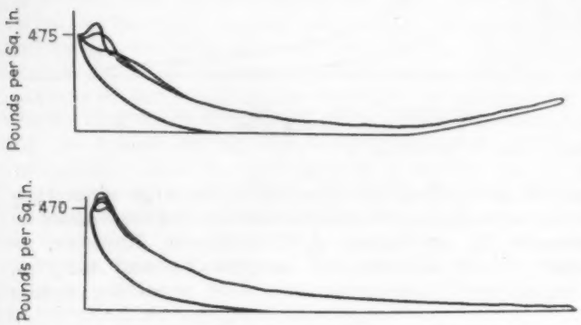


FIG. 4 (ABOVE) AND FIG. 5 (BELOW)—INDICATOR DIAGRAMS FROM AN OIL ENGINE IN WHICH FUEL IS SUCKED DURING THE INDUCTION STROKE

Fig. 6 shows a fuel plug, consisting of the fuel valve, needle valve and fuel pocket, for such an engine. In the ordinary automotive engine one simple device of this kind per cylinder supplants the carbureter, air stove, priming cocks, spark plugs, high-tension cables and magneto. In the mechanically timed fuel injection, constant-compression heavy oil engines the device supplants the fuel injection valves, governors, double extra strong piping, air bottles and triple expansion compressors. The desirability of so simple an engine in the automotive field is very apparent.

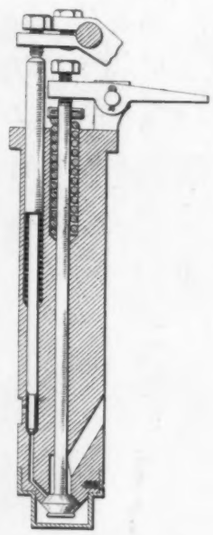


FIG. 6—FUEL PLUG, NEEDLE VALVE AND FUEL POCKET

Fig. 7 shows the combustion chamber of a single-cylinder engine of such a design, also the location of the complete fuel plug, which controls the amount and time of fuel injected. The combustion chamber differs from that in the ordinary gasoline engine only in the much smaller ratio of clearance volume to piston displacement and in having a fuel pocket in place of a spark plug.

During the induction stroke both the air valve *A* and fuel valve *B* are opened by the rocker arms actuated from a camshaft. This permits pure air to flow to the combustion space; at the same time air and fuel, the amount of the latter depending on the opening of the needle valve *E*, flow to the fuel pocket *D*. Both fuel and air valves close before the compression stroke begins. The heat generated by compression is sufficient to ignite the fuel, but the fuel in the pocket is in contact only with the oxygen in this pocket. Since the communication between the fuel pocket and the combustion chamber is through the minute holes *F*, by the time the initial combination of fuel with the adjacent oxygen has taken place and driven the remaining fuel into the combustion chamber, the piston has started on its working stroke. The timing of the fuel injected into the combustion chamber is determined by the size of the holes *F* in the wall of the fuel chamber *D*. If these holes are too large the unburned fuel would be driven too early into the combustion chamber by the force of the preliminary explosion, causing the "ping" of early ignition; and if too small, the piston will move too fast for the pressure behind it to be maintained.

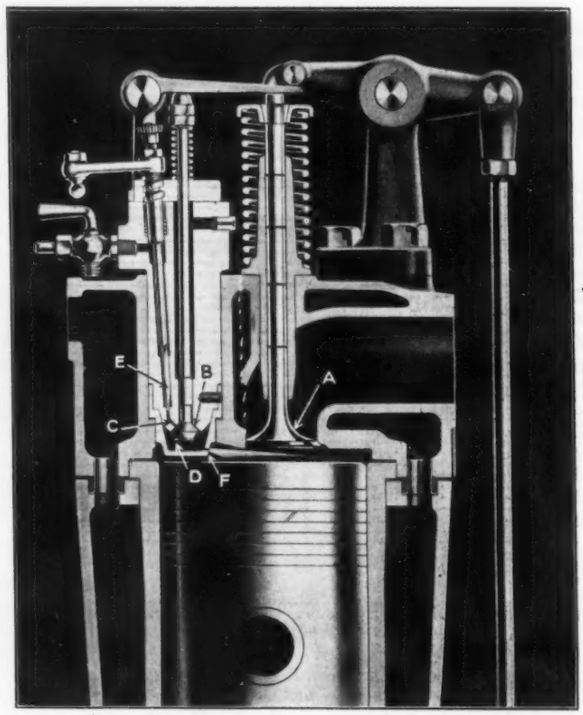


FIG. 7—COMBUSTION CHAMBER OF SINGLE-CYLINDER ENGINE, SHOWING LOCATION OF FUEL PLUG

Controlling the Ignition

Inasmuch as a change in the size of these holes changes the time of ignition, various sizes are used in different engines, just as different magneto settings are used in explosion engines. These holes are usually two in number, and are seldom larger than a No. 40 drill. One might expect them to become clogged, and they probably would if there were as much free carbon deposited as in many gasoline engines. On account of a more complete combustion, and consequent absence of carbon, and because of the extreme pressure variations, these holes or ports never become stopped up or burnt larger, even after years of operation.

It is readily seen that if these small ports through which the oil is driven to the combustion chamber are properly

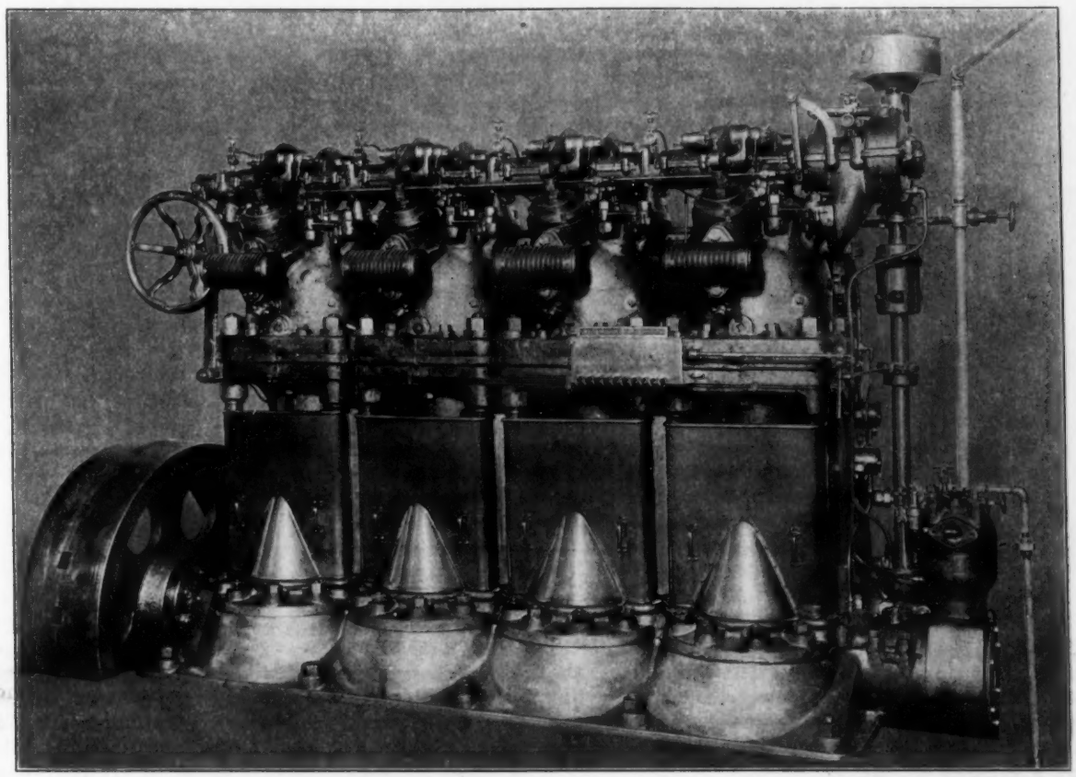


FIG. 8—LYONS-ATLAS 100 B. HP. HEAVY-OIL ENGINE. VERTICAL, FOUR-STROKE CYCLE TYPE
Four cylinders, 9 x 13 in., 350 R. P. M.

proportioned for correct timing, a change in the load, since it does not change the compression or the amount of combustion in the fuel pocket, will not appreciably change the time of combustion in the cylinder, but most careful analysis is required in order to comprehend why the holes, if proportioned for a maximum speed, will be correct for any speed, a condition found to apply in practice.

Assuming that these holes are correct for a maximum engine speed, one might expect that if the time of ignition is constant, and the engine speed is slower, the pressure will rise more rapidly than it would due to the piston motion, thus causing too early ignition and an excessive initial pressure. But when the speed decreases a greater amount of heat is absorbed by the cylinder walls during compression, and the temperature necessary to start inflammation is not reached so soon. Therefore, ignition will occur later as the speed diminishes; and conversely, if the speed is increased the ignition occurs earlier. But since the piston speed is greater, an earlier ignition is desirable to prevent a drop in pressure when the piston starts upon the working stroke.

In order to obtain the highest thermal efficiency in a gasoline engine the time of ignition should be advanced in direct proportion to the engine speed and inversely with the compression pressure. This principle has been advocated by the author for several years, but has yet to be attained in practice because it involves the use of automatic and most intricate compensating mechanism.

In a constant-compression engine of the gravity-feed type described above, and to which we will refer exclusively in the discussion below, the manifold pressure is necessarily constant and the timing of the ignition varies automatically and directly with the speed of the piston, thus maintaining a practically constant thermal efficiency without auxiliary mechanism.

Fig. 8 shows a four-cylinder 9 by 13-in. engine, which develops 100 b.hp. at 350 r.p.m. The illustration represents a stationary type, but it can be built reversing for marine work with a governor controlling the maximum or critical speed.

CONSTANT-PRESSURE PERFORMANCE

Fig. 9 shows vertical transverse and longitudinal sections through a 4¾ by 6½-in. gasoline engine rebuilt into an engine of the constant-compression type. This engine has been in operation about a year and has served to demonstrate the satisfactory timing of ignition under variable loads and speeds; from idling to full load, and from 180 to 750 r.p.m., the latter the maximum speed that the governor permits. As the spoked flywheel at 750 r.p.m. has a rim speed of 6250 ft. per minute, a higher rotating speed was not attempted, but there was nothing to indicate that it would not run at 1000 r.p.m. if a suitable flywheel were provided. With properly designed valves and ports the engine should have a maximum torque at this speed.

Fig. 10 is a side elevation and Fig. 11 a three-quarter view of a four-cylinder heavy oil engine with the same piston displacement as the engine shown in Fig. 9. This engine is built for truck and tractor applications and is expected to be built for reversing for marine work. A 25-hp. two-cylinder 6¾ by 9-in. marine engine, burning California fuel oil (26 deg. Baumé), is shown in Fig. 16.

While no heat balances or fuel-consumption tests have, to the author's knowledge, been made of these compara-

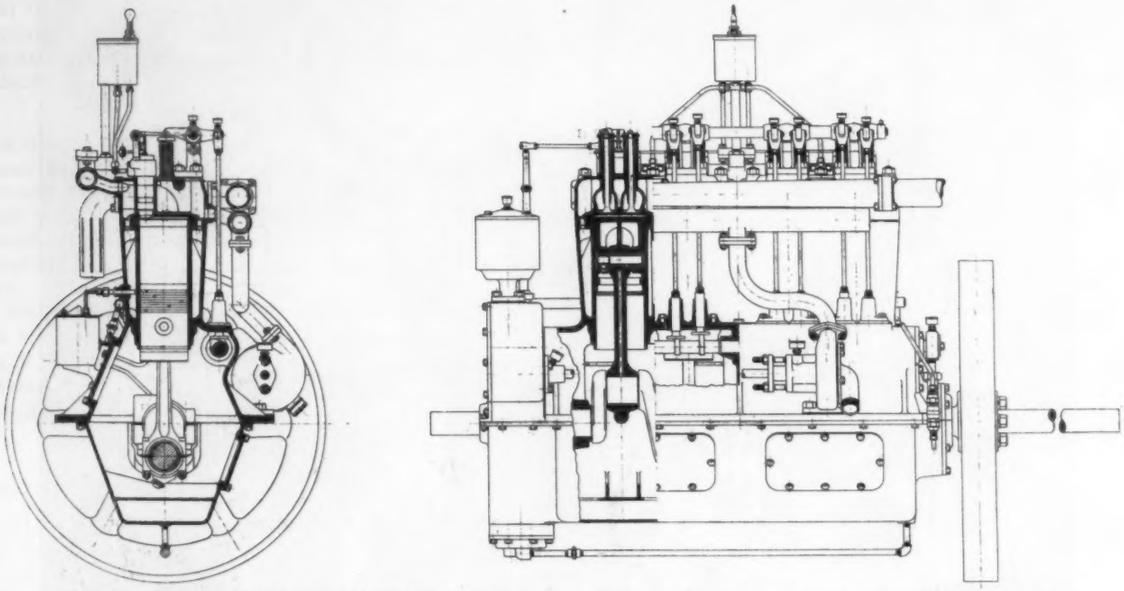


FIG. 9—SECTIONAL VIEWS OF A GASOLINE ENGINE REBUILT INTO AN ENGINE OF THE CONSTANT-COMPRESSION TYPE

tively small four-cylinder engines, Table I shows the fuel consumption per brake horsepower of a three-cylinder 9½ by 10½-in. stationary engine using different fuels. This indicates an efficiency seldom surpassed by engines of a greater output.

The load during all the tests was continuous, and fuel

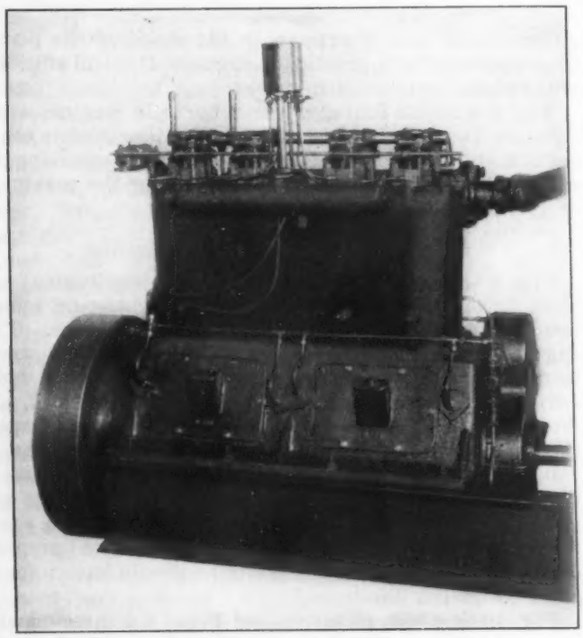


FIG. 10—SIDE VIEW OF FOUR-CYLINDER HEAVY OIL ENGINE FOR TRUCKS AND TRACTORS

changes were made without stopping the engine or removing the load.

Method of Starting

In order to crank an engine readily with 475-lb. compression it is necessary to relieve the compression until such a speed is reached that the inertia of the flywheel will carry the engine over one compression. If fuel is permitted to flow into the fuel cup during the induction strokes before compression begins, it may flow out by gravity into the combustion space, causing premature ignition.

Figs. 12 and 13 show a four-cylinder complete expansion thermo syphon-cooled engine now in process of build-

TABLE I—RESULTS OF TESTS OF THREE-CYLINDER HEAVY OIL ENGINE

Test No.	I	II	III	IV
Bore of cylinder, in.	9½	9½	9½	9½
Stroke, in.	10½	10½	10½	10½
Fuel	Kerosene	Mexican fuel oil	Standard Oil Co. fuel oil	Lansing fuel
Weight per gallon, lb.	6.9375	7.1875	7.375	6.9375
Weight per pint, lb.	0.8672	0.8984	0.922	0.8672
Gravity, deg. Baumé	42	33	29	39
Flash open flame, deg. F.	160	200	196	210
R.p.m.	315	330	345	340
Pounds pull net	191	191	191	191
Brake-arm circle circum., ft.	33	33	33	33
Torque, lb.-ft.	1003.3	1003.3	1003.3	1003.5
Horsepower	60.165	63.03	65.895	64.94
Fuel, lb. per b.hp. hr.	0.586	0.500	0.481	0.466
Operation of engine	Smooth	Very smooth	Smooth	Smooth
Exhaust	Clear	Trace of smoke	Almost clear	Trace
Engine troubles	None	None	None	None
Maximum b.hp. with slight smoke	60.16	85.00	84.15	86.70

ing, designed for truck and tractor service. In this the fuel valves are closed by the same mechanism that holds the exhaust valves open, thus eliminating the probabilities of premature ignition when the engine is started. Fig. 14 shows a cross section through No. 1 cylinder, the fuel valve, and one-half of the air admission valve, and Fig. 15 a longitudinal section through the center of the engine.

While this engine can be cranked much more easily than a gasoline engine of the same piston displacement, provision is made for the application of both an electric starter and generator.

The overhead camshaft works on the valves direct,

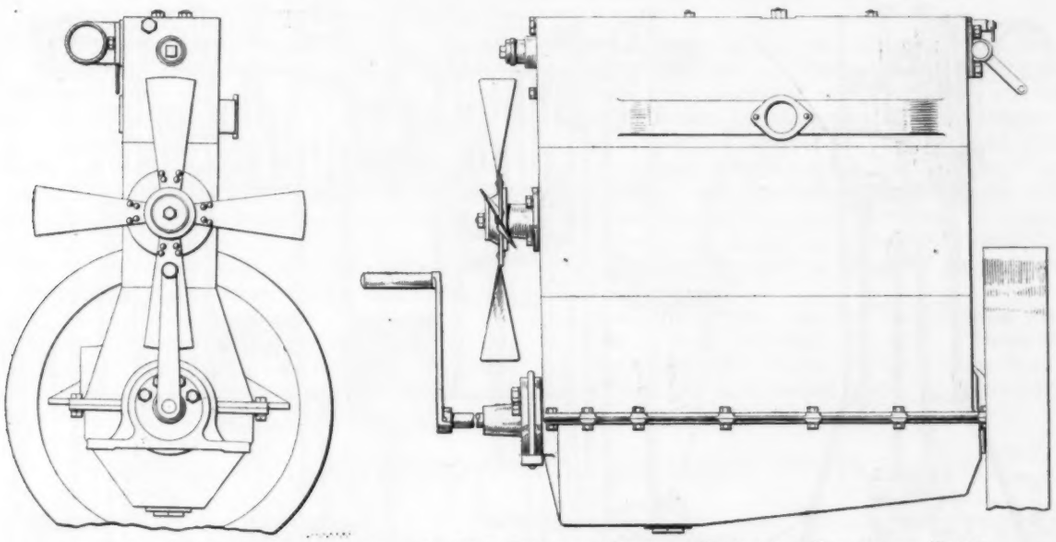


FIG. 12 (LEFT) AND FIG. 13 (RIGHT)—FOUR-CYLINDER COMPLETE EXPANSION ENGINE FOR TRUCK AND TRACTOR SERVICE

turning each a few degrees every opening. The camshaft is driven by two pairs of bevel gears and the fan by one pair from the vertical shaft. The force-feed oil pump, doweled in the bottom of the lower crankcase, is driven by the gear on the crankshaft. This pump is attached to the lower case. Oil is delivered under pressure to the crankpins and main bearings and through the hollow camshaft to the upper parts of the valve mechanism. The cylinder head, containing valves, camshaft, governor mechanism and fuel valves, is removable; its walls are carried above all moving parts so that plates cover all the mechanism, thus keeping the oil in and the dust out.

The inlet and outlet water openings are shown by dotted lines. The crankshaft is anchored at the front bearing, thus keeping the pitch circles of the driving gears in their proper location.

By rotating a semi-cylindrical cam 90 deg. by use of a lever just above the flywheel the camshaft is moved forward against the governor spring, causing the cones on the camshaft to hold the exhaust valves open and the cone on governor to close all needle valves. The fuel is thus prevented from entering the cylinder until compression begins. During normal operation the flyballs move the governor cone against the spring in proportion to the speed, thereby proportioning the fuel supply to the load.

If in truck or traction installations the short arm—also above the flywheel, and fastened to the governor shaft—be so connected that when the clutch is moved to the neutral position the fuel is throttled, then the engine speed is automatically reduced to an idling speed when no work is being done. The air for the fuel valve is taken from the filtered air in the manifold, and the fuel is supplied to the needle valves through holes drilled in the cylinder head.

The friction-drive fan is of large diameter, and, with so little engine area in the path of the discharged air, ought to be highly efficient. With a fixed fan center, the radiator shroud, so essential in continuous and heavy work, need be but slightly larger than the fan, eliminating any back or eddy currents.

The lubricating oil, in flowing to pump suction, passes vertically through a gauze strainer, thus depositing foreign matter in the pocket below.

Valve Timing

The fuel valve is opened on top center and remains open 180 deg. during the induction stroke. The exhaust

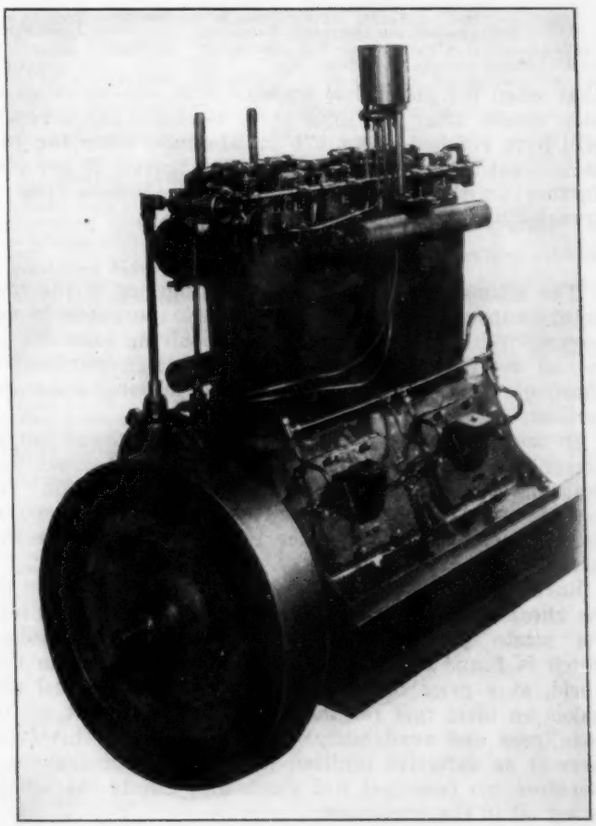


FIG. 11—ANOTHER VIEW OF ENGINE SHOWN IN FIG. 10

valve opens 20 deg. before the end of the working stroke and closes on top center. The air valve opens on top center and stays open until the piston has traveled 1½ deg. on the compression stroke. The clearance is such

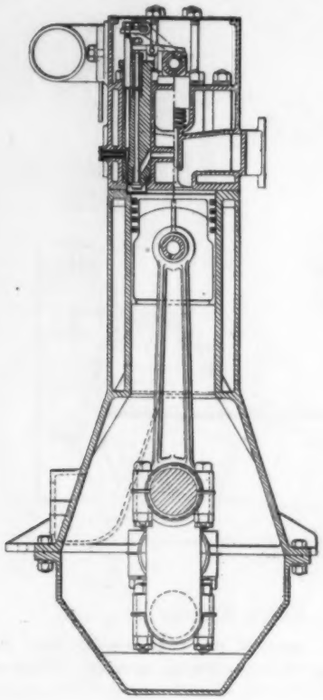


FIG. 14—CROSS SECTION THROUGH CYLINDER OF FIG. 12

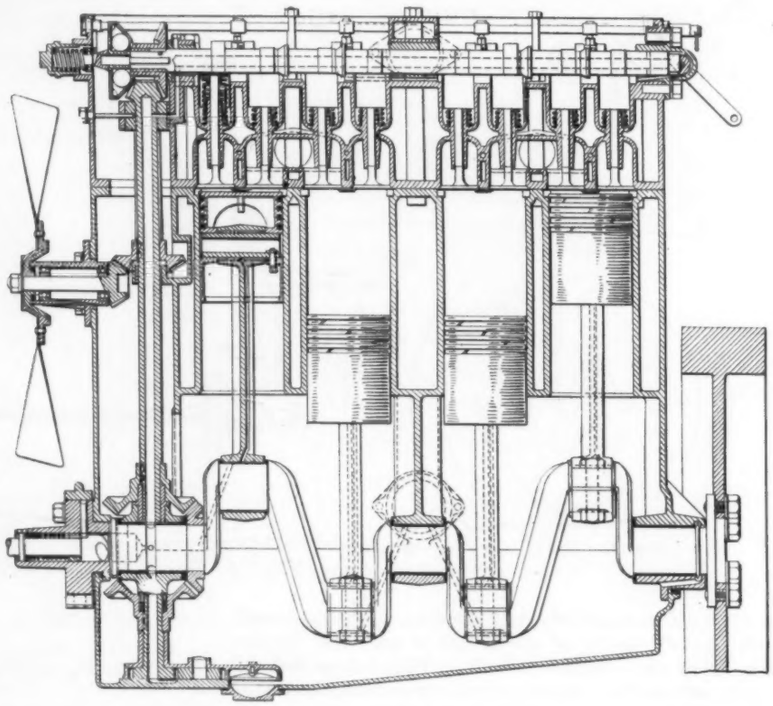


FIG. 15—CROSS SECTION THROUGH CENTER OF THE ENGINE SHOWN IN FIG. 13

that when the piston has traveled 5 in. on the compression stroke after the inlet valve is closed the pressure will have reached about 475 lb. absolute, when the fuel is automatically injected. The piston travels 20 per cent farther on the working stroke before release than it traveled during compression.

AUTHOR'S CONCLUSION

The ultimate success of heavy oil engines of the constant-compression type for automotive purposes is apparent. While problems may arise requiring some changing of details, the simplicity of the design warrants a thorough development of the prime mover herein described.

In the stationary field about fifty-five thousand horsepower of engines of this type is in use and about five thousand horsepower is being produced each month. Its manufacture for automotive transportation purposes promises to become a matter of great interest to the members of this Society.

Burning any liquid hydrocarbon, it can make use of the cheaper products of the refinery, or even liquid tar, the waste product of coke-oven plants. Kerosene, which is found at almost every crossroads store in the world, at a price but little more than that of fuel oil, makes an ideal fuel for these engines on account of its cleanliness and availability. In an engine of this type there is no defective ignition with normal compression; therefore, no free fuel will reach and vitiate the lubricating oil in the crankcase.

With a combustion in every cylinder, irrespective of the load, carbon will not be deposited, for burning the carbon out is a continuous performance. With a heavy fuel the danger of fire is greatly reduced, and when this constant-compression engine is applied to airplanes we will seldom read of their descending in flames. By reducing fuel consumption one-half, even should the price of fuel oil and kerosene reach that of gasoline, there would be affected a saving of the greatest magnitude.

The heavy oil engine as a prime mover for the automotive purposes is most promising, and in the author's opinion will have a phenomenal growth.

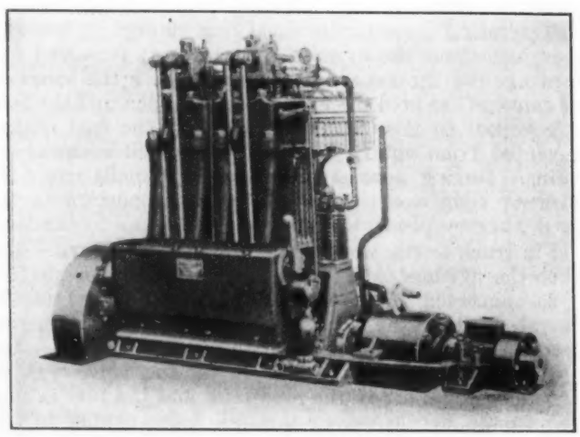


FIG. 16—HEAVY OIL ENGINE FOR MARINE USE

In conclusion, the author desires to thank R. M. Hvid, member of the Society, for the illustrations, Figs. 7, 9, 10, 11 and 16, and for the results of the engine tests incorporated in this paper.

OUTLINE OF MOTOR VEHICLE COURSE

A COURSE in motor vehicle engineering at Cooper Union, New York, is especially designed for those who are engaged during the day in automobile design, construction, testing, drafting, or repair work, or in some branches of engineering, and who wish to obtain a thorough knowledge of motor vehicle design and testing.

The object of the course is to fit men for positions of higher responsibility, and it is being conducted by Ethelbert Favary, M. S. A. E.

A study of the principal parts of motor vehicles and the theory underlying their proper design and construction will be given in classroom work.

The laboratory work will consist in the study of the operation of engines and the factors affecting the indicator diagram and how to determine faulty design and construction from such diagrams. The testing of engine power by prony brakes and dynamometers, the study of magnetos, efficiency of transmissions, differentials, bearings and other parts of motor vehicles will also be included, as shown in the synopsis of the course.

The laboratory equipment includes one Mack truck, one six-cylinder Continental engine, one four-cylinder Buda engine, one Sturtevant eight-cylinder airplane engine, one touring car, and a number of such parts as rear axles, front axles, counterbalanced crankshafts, camshafts, pistons, magnetos, steering gears, springs, and other accessories.

There is no tuition fee, the course being given in the interest of the automobile industry. Those wishing to enroll for the next season, which begins Oct. 1, *should write now* for application cards to Secretary, Cooper Union, New York.

SYNOPSIS OF COURSE IN MOTOR VEHICLE ENGINEERING

The Gasoline Engine
Cycle of operation;
Limits of compression;
Expansion pressures;
Most efficient point of ignition;
Combustion of gases;
Timing of valves.

Gas, Gasoline Vapor
Compression, combustion and expansion of gases;
Boyle's law; isothermal curve;
Gay Lussac's Law; adiabatic curve;
Coefficient of expansion;
Formulas for determining pressures, expansions, volumes and temperatures;
Properties and chemical composition of gasoline;
Variation of gravity of gasoline;
Proportion of air for perfect combustion.

Clearance and Compression
Compression and clearance ratios;
Calculating pressures;
Types of combustion chambers;
Combustion chamber temperatures;
Loss of heat during expansion;
Efficiency affected by water-jacket temperatures and cooling of cylinder walls;
Compression and efficiency.

Power of Engine
Theoretical horsepower;
Brake horsepower; methods of testing;
Prony brake;
Tests by dynamometer;
Road tests.

Sleeve and Rotary Valve Engines

Two-Stroke Cycle Engines

Airplane Engines

Cylinder Design and Cooling
Bore and stroke formulas;
Design of cylinders for a given power;
Thickness of cylinder walls; depth of water jacket;
Grouping of cylinders;
Cylinder construction;
Water cooling;
Thermosyphon and forced circulation;
Air cooling.

Valves
Valve dimensions;
Operation of valves;
Valve disks, seats, and stems;
Metals for valves;
Construction of valves and valve passages;
Valve locations;
Push-rod mechanism and valve lifter levers;
Different mechanism for operating valves.

Cams and Camshafts
Effects of proper and improper designs of cams upon indicator diagram;
Most efficient points for opening and closing of valves;
Cams for high-speed and low-speed engines;
Timing of valves and cam designs.

Pistons and Connecting-Rods
Design and construction of pistons;
Cast iron, aluminum and steel pistons;
Piston rings;
Wristpins;
Design and construction of connecting-rods.

Crankshafts, Bearings and Flywheels
Different crankshaft constructions;
Dimension and proportions of crankpins and shafts.

Crankshaft Balancing
For static, running and distortion balance.

Crankshafts, Bearings and Flywheels
Vibrations of unbalanced crankshafts;
Offset crankshafts;
Carbon steel and nickel steel crankshafts;
Bearings;
Bearings for multi-cylinder engines;
Dimensions of bearings;
Necessity for flywheels;
Flywheel diameter;
Formulas for flywheel weight and area;
Flywheel design.

Fuel Mixing Devices
Carbureters, vaporizers and jets;
Design and construction of carbureters;
Conditions affecting carburation;
Effect of compression, temperature, speed and atmospheric changes on carburation;
Compensating air valves;
Single and multiple jet vaporizers.

Electric Ignition
Primary electric ignition;
Induction coils;
High-tension ignition;
Spark-plugs, tremblers, condensers;
Commutators and high-tension distributors;
Primary and secondary circuits;
Batteries, dynamos and magnetos.

Electric Starters and Electric Lighting
Single unit and double-unit systems;
Driving connections to engine;
Electric lighting circuits;
Electric wiring.

Transmission or Change-Speed Gears
Sliding gears;
Planetary gears;
Individual clutch system;
Design and construction of transmission gears;
Pitch and dimension of gears;
Ratios at various speeds;
Factor of safety and metal used for gears;
Formulas for determining driving force, horsepower transmitted.

Differential or Balance Gears
Design of differential gears;
Bevel gear differential;
Spur gear differential;
Worm gears.

Clutches
Design and construction of clutches;
Leather-faced cone clutches;
Expanding clutches;
Disk clutches;
Materials for disks;
Formulas for determining torsional resistance, twisting moment and horsepower to be transmitted;
Coefficient of friction;
Angle of cone;
Formulas for determining diameter, area, and strength of clutch springs for given power.

Mufflers or Silencers
Design and construction of mufflers;
Cooling of mufflers and exhaust manifolds;
Volume of mufflers for multi-cylinder engines;
Muffler explosions.

Chassis and Frames
Pressed steel, channel, armored wood and angle-iron frames;
Design and construction of frames;
Materials for frames.

Springs
Design of vehicle springs, half elliptic, full elliptic and cantilever springs.

Axles
Front and rear axles;
Divided and solid axles;
Round and I-section axles.

Steering Devices

Wheels

Brakes

Rolling Resistance of Tractor Wheels

By Amos F. Moyer* (*Member of the Society*)

Minneapolis Section Paper *Illustrated with* Charts

PHYSICISTS define a plastic body as one which can be molded under pressure, recognizing that the rate at which deformation is produced often affects materially the plasticity of the substance. Funk & Wagnalls' New Standard Dictionary states that the body must permit "molding of form," which might lead to the assumption that the volume is to remain unaltered.

The freshly tilled, sandy, black loam soil used for the experiments described in this report not only is capable of molding in form but is to a slight degree compressible as well. The yielding properties of the soil, however, appear to be due to lateral movement under vertical pressure to a much greater extent than to the compression of any given amount into smaller volume.

The mathematical derivations which it was desired to verify by these experiments are based on the assumption that soft soil, and probably other plastic materials, bear up a unit pressure proportionate to the depth of depression. This is equivalent to saying that the total weight borne up is proportionate to the volume perpendicularly inclosed by the displacing surface in actual contact with the substance and below the surface from which the substance was displaced. In the case of a hard cylindrical body rolling on a level plastic surface this volume consists of the prismatic half segment of the cylinder below the level surface and on the forward side, as illustrated in Fig. 1.

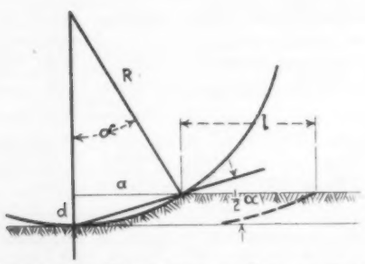


Fig. 1—Illustrating Depression of Soil by Tractor Wheel

If the deforming body, instead of being a cylinder, were rounded upward in front and continued flat for some distance backward, so as to rest in contact with the bottom of the track, like a sled runner or tracklayer tread, the supporting volume of displacement would include also the rectangular prism extending backward a distance equal to the flat supporting surface. This illustrates the much greater carrying capacity which characterizes such surfaces.

Throughout the detailed studies and experiments thus far conducted, attention has been confined to plain flat-tired wheels of varying weight, width and diameter. Since the parabolic area (see Fig. 1) is equal to 2/3 *ad* the law already outlined for a cylindrical body or plain flat-tired wheel is expressed as follows:

$$W = \frac{2}{3}\, ad\, Fn \qquad (1)$$

where W = weight on wheel, pounds;
F = width of tire face, inches;
n = bearing value of soil, pounds per cubic inch.

But since $a = R \sin \alpha$ and $d = R - R \cos \alpha$,

$$W = \frac{2}{3} Fn\, (R^2 \sin \alpha - R^2 \sin \alpha \cos \alpha)$$

$$= \frac{2}{3} F R^2 n\, (\sin \alpha - \tfrac{1}{2} \sin 2\alpha)$$

$$\frac{W}{\frac{2}{3} F R^2 n} = \sin \alpha - \frac{1}{2} \sin 2\alpha \qquad (2)$$

which expresses a similar law in terms of the wheel dimensions and the arc α, which is in contact with the soil.

According to the principle of the conservation of energy, the work done in rolling a wheel a given distance must be equal to that expended in depressing the soil over the same distance. This fact, expressed mathematically,† results in

$$G = \frac{P}{W} = \frac{3}{4} \tan \frac{1}{2} \alpha \qquad (3)$$

Here P represents resistance or pull (in pounds) required to roll the wheel, and this divided by the weight on the wheel is G, or the equivalent grade. This is the percentage grade up which the wheel would have to roll without friction on a hard surface to give the horizontal resistance P. The term ¾ tan ½ α, or three-fourths of the slope of the chord subtending the arc of contact, is a considerably smaller quantity than some of the catalogs of caterpillar tractors would have us believe for the loss in rolling a round wheel. One such catalog gives 41½ per cent equivalent grade for a 6-ft. wheel sunk in the soil 3 in., whereas the law just derived gives 15.6 per cent.

Referring again to (2), it is evident that the factors in the denominator other than n are proportionate to the cylindrical volume of the wheel, which we may call Q. Throughout the calculations this has been expressed in cubic feet, so that W/Q which is designated as S, or specific load, is written in pounds weight per cubic foot of wheel volume. The mathematical proof that the rela-

*Experimental Engineering Department, University of Minnesota.

†The mean unit press. $= W/FR\sin\alpha = 2/3$ max. unit press. Therefore the max. unit press. $= 3/2\ W/FR\sin\alpha$ and varies as the depth from zero at the surface. The work per unit area $= d \times \frac{1}{2} \times 3/2\ W/FR\sin\alpha$ and the work of depression over distance l with resistance P is $dFl \times 3/4\ W/FR\sin\alpha$, which equals Pl. $P/W = 3/4\ d/R\sin\alpha = 3/4$ slope of chord $= 3/4 \tan \frac{1}{2}\alpha$

tion between S and G is fixed, whenever n remains constant, is as follows:

$$\frac{W}{\pi R^2 F} = \frac{2}{3}\pi(\sin\alpha - \frac{1}{2}\sin 2\alpha)n \text{ and } \frac{W}{Q} = S = f(\alpha)$$

From (2)

also

$$\frac{P}{W} = G = f'(\alpha) \qquad \text{From (3)}$$

Therefore when n is constant G has a fixed relation to S. I am indebted to Profs. W. E. Brooke and C. F. Shoop, each of whom made an independent solution eliminating α from equations (2) and (3) for the expression of the exact relation between these quantities, which is:

$$S = \frac{281{,}440G^3n}{(16G^2+9)^2}$$

$$\text{or } n = \frac{S(16G^2+9)^2}{281{,}440G^3} \qquad (4)$$

Experimentally it has been easy to determine S and G so that equation (4) has been very useful in studying the values of n.

It can be shown that $\cos\alpha = \sqrt{2P/FR^2n} - 1$ and $d = R - R\cos\alpha$, so that:

$$d = \sqrt{\frac{2P}{Fn}} \qquad (5)$$

$$P = \tfrac{1}{2}d^2Fn \qquad (6)$$

This interesting deduction results in equation (5) expressing depth of depression and (6) expressing resistance. Such a simple expression as (6) seems almost uncanny when we realize that if we know enough about the soil, that is, if we know n we can tell the resistance of a wheel if we never see anything but the track.

Recording Dynamometer Built

Desiring to verify some of these deductions, it seemed necessary to provide a course where conditions could be as quickly and as nearly duplicated as possible in order to obtain a large number of comparable readings. The only condition possible of quick duplication seemed to be freshly tilled soil, making possible the repeated use of one and the same bed. This condition at once suggested the use of a stationary dynamometer, which would measure the pull required to move loaded wheels by means of ropes. Knowing the value of averages for such readings, a recording dynamometer, Fig. 2, was designed and constructed.

Here the rope r is shown leading in from the left horizontally as in pulling a wheel. The sheave A is mounted on the vertical strut B, which in turn is pivoted opposite the lower sheave C in such a position that when C is driven at the required speed the rope in passing downward is parallel to B. This portion of the rope therefore produces no rocking reaction in B, while the horizontal portion exerts a force P, which is transmitted to the flexible tension member D. The right-hand end of D is wrapped over the top of the shaft E. This shaft terminates at both ends in small diameter trunnions which rest on the periphery of the large rollers F, thus greatly reducing the friction. Upon E is mounted the pendulum G, the horizontal displacement of which will be proportionate to the pull P in the rope.

On one extremity of E is mounted the crank-arm H, to which is pivoted the arm I. The lower extremity of I is attached to a link and constrained to move only in a vertical line, so that pencil J at the upper end of I describes a straight horizontal line after the manner of the Thompson indicator pencil motion. Since H is in line with pendulum G, the recording pencil J will move horizontally always in fixed proportion to the pull P. To damp the oscillations of the pendulum a loose-fitting oil dash-pot is provided as shown.

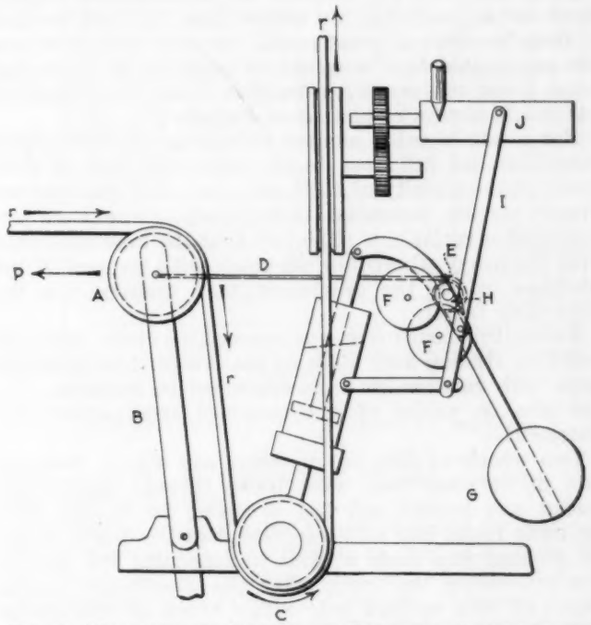


Fig. 2—Diagrammatic Layout of Recording Dynamometer

The recording paper feed is driven by the ascending rope passing over a large transverse sheave, which in turn is geared to the recording drum so that ½ in. on the record represents 1-ft. movement of the rope. Two interchangeable pendulum weights, one of lead and one of cast iron, have been employed, giving record scales of 80 and 40 lb. per inch respectively. With the lead weight the dynamometer will record pulls up to 250 lb.

Fig. 3 shows a typical record. The peak wave at the left-hand end is caused by the inertia effect at starting

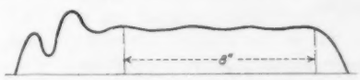


Fig. 3—Typical Dynamometer Record

the wheel. A portion of the record is selected representing average conditions and the area determined by the planimeter over a measured length, thus establishing the average pull.

The soil bed employed was at first 3½ ft. wide—later widened to 5 ft.—and 8 in. deep, of sandy black loam with only sufficient moisture to avoid dust and ball slightly when compressed in the hand. A pair of wheels were mounted rigidly on a shaft with two ropes leading to the dynamometer. These ropes were permitted to unwind from the shaft as the wheels advanced, thus eliminating bearing friction. Wheels were easily interchanged, and increments of load were obtained by fastening weights to the wheels in any balanced position.

Early Experiments

The deductions regarding G and S were suspected before they were proved, so that we early began seeking for the relation between the two quantities. While the

studies have not yet resulted in mathematical expressions for all variables, we believe that the time devoted to them has been of great profit. On first thought it was not anticipated that n would be anything but constant for a given soil condition, so that S and G of equation (4) would always be plotted as a single line.

For a considerable number of the earlier tests these quantities did fall close to the same line, but at slow speed, in the vicinity of 20 ft. per min., with the heaviest wheels moving somewhat more slowly, there were unaccountable variations. The fact that the readings taken with the heavy wheels did not check with the rest of the readings led to the conclusion that velocity was the disturbing factor.

Before this conclusion was reached, however, some interesting studies were made on the law of three-quarters slope with relation to G as expressed in equation (3), and also on values of n determined from actual displacement.

Two wheels of 33¾-in. diameter and 4⅝-in. face, set 13½ in. between tires, were drawn through the freshly spaded and leveled soil bed at about 20 ft. per min. for light loads, but at lower velocities for heavy loads. An attempt was made at first to determine the depression by scaling the track after the wheels had passed over. By this method only a fair check of the law of three-quarters slope was obtained, but values of n calculated from displacement varied as much as 300 per cent. It became evident that the track was not the true level to which the wheel sank in passing over the soil. Next a series of 20 swinging stops was arranged above the course so that as the wheels passed beneath each stop would be pushed up to and left at a point marking the position of the tire of the moving wheel. In this way it was proved that the bottom of the track is higher than the lowest point of the tire. The amount of this difference was measured as carefully as possible, taking into account several allowances for inaccuracies of hastily constructed apparatus, and from these data the gratifying check on the law of three-quarter slope expressed in equation (3) was obtained ranging from 0.726 to 0.777 for the value of three-fourths in the formula. Values of n also became much more nearly constant, ranging from 4.28 to 6.27. Subsequently it became evident that this variation was probably caused by diminished velocity at the heavier loads.

Varying Velocities

Fig. 4 illustrates the amount of labor involved in making a comprehensive study of the effect of velocity on the resistance of a single size of wheel. For each point or observation it was necessary to spade up by hand the entire 3½-ft. by 25-ft. course. (Considerable credit should be given to the student assistants who, because of interest taken in the problem, worked at this long hours at low pay.) This represents the resistances obtained for a pair of wheels, 24¼-in. diameter by 6¼-in. face, pulled at varying velocities with six increments of load. The lines show clearly that resistance increases with velocity for each weight on the wheels, and that this increase is somewhat more rapid with heavy loads than with light loads. All these lines when produced were found to intersect at the left in a common point representing zero resistance and a negative velocity of 1013 ft. per min. or minus 159.4 r.p.m. The full meaning of this is difficult to comprehend, but the fact is nevertheless of value to us in making deductions.

By reading off the intersections on any ordinate

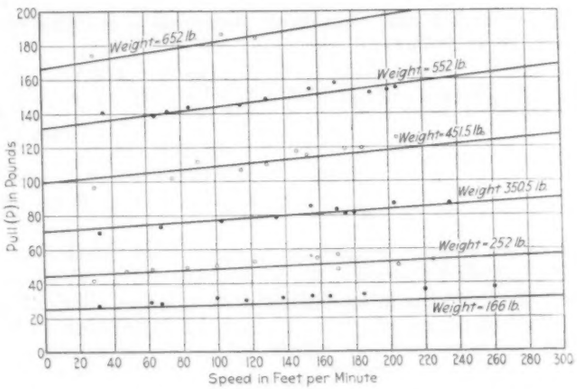


Fig. 4—Resistances for a Pair of Weighted Wheels
Wheel diameter 24¼ in. Face 6¼ in.

representing a desired speed, values for P will be determined of greater accuracy than if the readings were taken at precisely that speed, since the variation of points from the line indicates the considerable error in a large proportion of the individual readings.

From the theoretical equation (4) giving n in terms of S and G, and the values determined from intersections, it was ascertained that the value of n remained virtually constant for each speed, but varied for different speeds. It was by use of the average value of n obtained from the other lines on this plate that the lower line was dropped below the points of observation, assuming that there had been some undetected error in these readings.

Fig. 5 represents results from the intersection readings at 205 ft. per min. or 2⅓ m.p.h. after the values have been converted to S and G, specific load and equivalent grade. The six points shown correspond to constant values of n, and the curve produced to the origin is obtained by substituting this same value in the theoretical equation. As the general form of this curve, which may be called a characteristic, suggests the parabola, a determination was made by trial of the parabola having the analytic form $y^2 = 2px + a$, which most nearly corresponds to the actual curve throughout the practical range of values. This parabola is shown by the dotted line, which coincides with the full line throughout the right-hand part of the field, and probably for some distance beyond. The equation of this parabola, which ex-

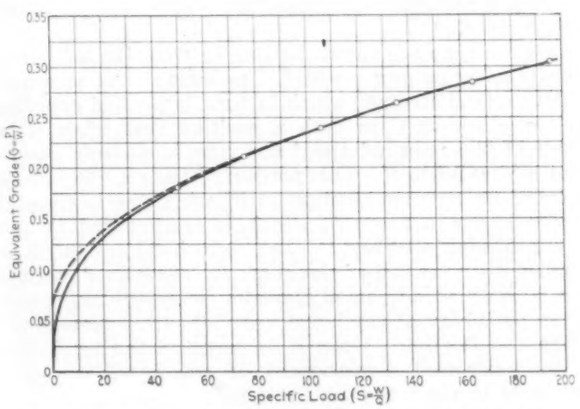


Fig. 5—Showing Relation of S to G at 205 Ft. Per Min.
(Equation 4)

Dotted line shows relation of S to G, based on parabolic equation 7

presses G in terms of two constants and the square root of S, is as follows:

$$G = 0.0175\sqrt{S} + 0.060 \qquad (7)$$

Since S is weight per cubic foot of wheel volume, the equation may be rewritten with a constant divided by the diameter outside of the radical, and weight per inch of tire face under the radical, giving a simple formula for G in terms of weight and wheel dimensions. Unfortunately however this formula cannot be universally applied, as will be shown later.

When readings are taken at different ordinates representing increments in velocity, values of n will be obtained, each of which gives a different characteristic curve corresponding to the speed. Fig. 6 shows this series of curves determined from the same data obtained from the 24¼-in. by 6¼-in. wheels. Each of the lines represents a certain velocity corresponding to a different value of n. Since n to the first power is the common factor, the variation of which shifts the position of the curve, we may

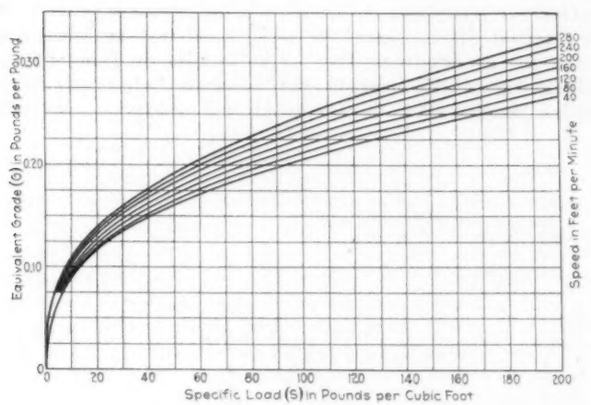


FIG. 6—SHOWING RELATIONS OF S TO G AT VARIOUS SPEEDS

divide through by this and plot G against S/n when all the curves unite into a single line, Fig. 7.

Here are represented seven different velocities and six different weights, or forty-two possible values, all of which fall on the same line. In the theoretical equation

$$\frac{S}{n} = \frac{281{,}440G^2}{(16G^2 + 9)^2} \qquad (8)$$

it is evident that if the right-hand member can be approximately written as an exponential of G, it will be possible to express G in terms of S/n. To accomplish this the points were transferred to logarithmic plotting paper, giving the straight line shown in Fig. 8. This gives the following approximate exponential equation

$$G = 0.0588\left(\frac{S}{n}\right)^{0.358} \qquad (9)$$

which is universally applicable for values of S/n between 10 and 100, provided n is known for the conditions obtained. If S were expressed in pounds per cubic inch of wheel volume instead of pounds per cubic foot, the value of the constant 0.0588 would of course be altered. Since n, the displacement value of the soil, is already given in pounds per cubic inch, the parenthesis S/n would then become a mere ratio of specific wheel-load to displacement value. On ordinary plotting paper values of S/n between 100 and 300 have nearly a straight-line

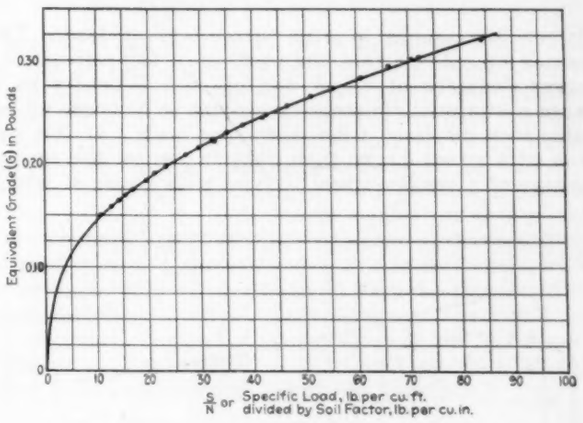

Equivalent Grade (G) in Pounds
0.30
0.20
0.10
0
0 10 20 30 40 50 60 70 80 90 100
S/N or Specific Load, lb. per cu. ft. divided by Soil Factor, lb. per cu. in.

FIG. 7—RELATION OF $\frac{S}{n}$ TO G, BASED ON EQUATION 8

relation to G, as represented by the equation $G = 0.00140S/n + 0.210$.

The laws concerning the values of n are not yet completely ascertained. As shown in the data from this individual pair of wheels, n varies with the velocity. This relation was determined for the case and plotted in Fig. 9. The slight curvature and downward slope would indicate that n probably becomes zero at high or infinite volocities. On the other hand there were indications of zero resistance to rolling at a velocity of minus 1013 ft. per min., corresponding to infinite values of n, which was therefore plotted on logarithmic paper against 1013 plus velocity. Fig. 10 shows this to be another straight line in a position representing the following hyperbolic function equation:

$$n = \frac{74{,}990{,}000}{(1013 + V)^{2.413}} \qquad (10)$$

VARYING DIAMETER

But this expression for n was determined from the same single pair of wheels, where one or more lines had been "doctored" to make n uniform for each speed. While a fair check has been obtained from other widths of the same diameter, other diameters show a consistent variation. A pair of larger diameter, 33¾ by 4⅝ in., not only gave different values of n at corresponding speeds, but at any given speed there was also a con-

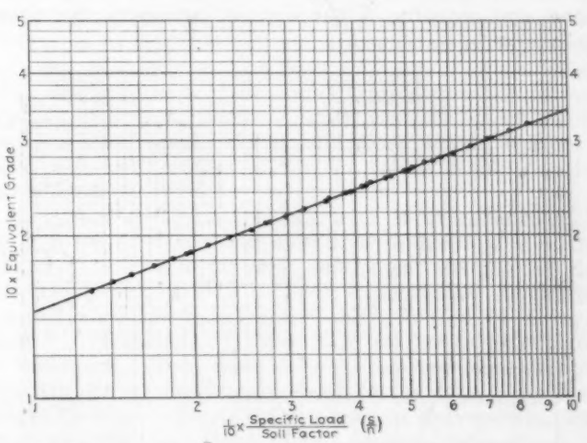


FIG. 8—RELATION OF $\frac{S}{n}$ TO G PLOTTED ON A LOGARITHMIC CHART (EQUATION 9)

sistent increase in n with increments of load. This seemed to indicate that the packing of the soil under a larger diameter of wheel was of such a nature as to cause a continually increasing amount to be borne up per cubic inch displaced with increasing loads. If this was true of a wheel larger than 24¼ in., would the reverse be true of a smaller wheel? Trial with a pair of wheels

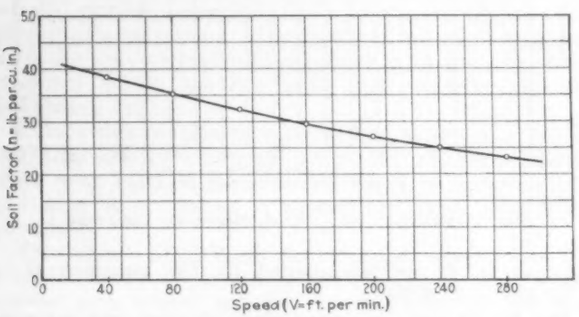


FIG. 9—SHOWING HOW BEARING VALUE OF SOIL VARIES WITH SPEED

of only 15¼-in. diameter proved that with increasing loads decreasing values of n were obtained at any speed. This indicated another law as affecting the value of n, it appearing that only one diameter would give a constant n for each speed.

One or more lines on Fig. 4 did not coincide well with the points obtained in the tests on the 24¼-in. wheels, and it was found after making corrections that there was also a variation in this case in one respect similar to that found with both the other diameters. Instead of the lines representing constant n being true ordinates, as assumed in Fig. 4, they were found to be curved and concave to the left, being tangent to the vertical at about half their height.

The 15¼-in. wheels gave lines of constant n concave to the left but sloping backward, while the 33¾-in. wheels gave similarly concave lines, but sloping forward. Apparently larger diameters will give these lines more nearly flat, but curved in the same direction. The nature of the curves obtained are such as to render a mathematical representation difficult. Each line of constant n for large wheels is relatively flat at the left and curves upward more rapidly at the right. With all wheels of larger size than about 24 in., increments in diameter have not only the effect of increasing the volume of the wheel and reducing S but also of increasing the value

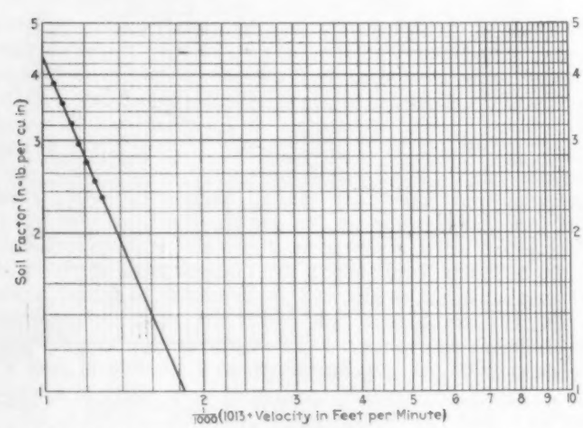


FIG. 10—VALUES OF SOIL FACTOR BASED ON EQUATION 10

of n, so that S/n is materially reduced, and hence also the value of G as expressed in equation (9). This argument then favors large diameter for load-carrying wheels.

As regards the variation in resistance with change in velocity, it is encouraging that wheels of different diameters show coherent results in the point of intersection of the produced resistance lines, as referred to on Fig. 4. This intersection occurs at zero resistance and minus 159.4 r.p.m. for all wheels, the value of 1013 ft. per min. applying only to the 24¼-in. diameter. It therefore appears that there remains one important law which it is not yet possible to write mathematically, namely, the variation of n with wheel diameter and depth of tillage. When this can be done it will be possible from the foregoing to express a general wheel-resistance formula involving the ordinary variables in a manner convenient for practical use.

After all of these determinations for the value of n are made, it may be asked whether the values actually represent weight borne up per cubic inch of soil displaced, or merely a hypothetical "something" which will satisfy a complicated equation. In obtaining data on the actual displacement of soil, there was no means at hand for ascertaining the "wave" action in front of the advancing wheel, merely the volumes being calculated which were below the original soil surface. Actually

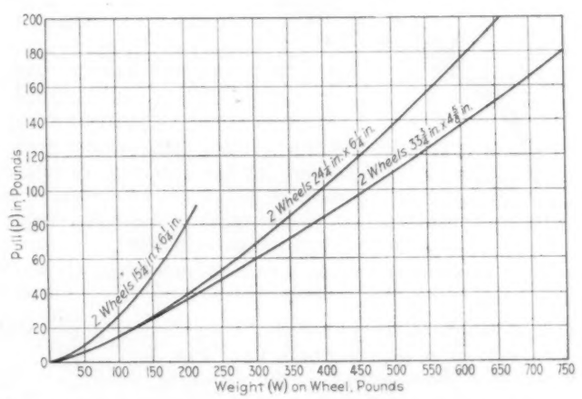


FIG. 11—RELATION OF W TO P FOR THREE SETS OF WHEELS
Speed 205 ft. per min.

this wave action plus the movement of the small bank of loose earth which always forms in immediate contact with the tire effect a greater virtual displacement than would be obtained by the method last described and hence a smaller value of n. This is also what is obtained by the mathematical determination of n from S and G. Thus we see that the mathematical determination of n takes into account several variables which would be difficult to determine by measurement. When the laws of variation of n are once determined, the values thus established will give true values of resistance, since resistance is the quantity whence they were derived.

In many theoretical solutions of engineering problems, quantities are encountered which make difficult the mathematical expression of exact relations, and short cuts based on experiment are often expedient. Fig. 11 shows directly the experimental results from the three sizes of wheels previously discussed. From these curves of P against W at 2⅓ m.p.h. some interesting deductions can be made.

Using any desired increments in weight per inch of tire face, the total load W and resistance P can be de-

termined, and hence also G, which equals P/W. These values independently determined for each wheel size are plotted against diameter in Fig. 12. Up to date we have only three points of observation on these curves and in several instances but two. It seems reasonable to expect, however, that these lines are of a quasi-hyperbolic nature, as we would expect G to diminish with large diameters and to increase rapidly with absurdly small wheels if the weight per inch of tire face were kept constant. A chart of this kind when completely determined over wide ranges of diameter and load will in many respects be as useful as a theoretically correct formula. Indeed, it may be found possible to develop an empirical formula representing approximately this series of lines.

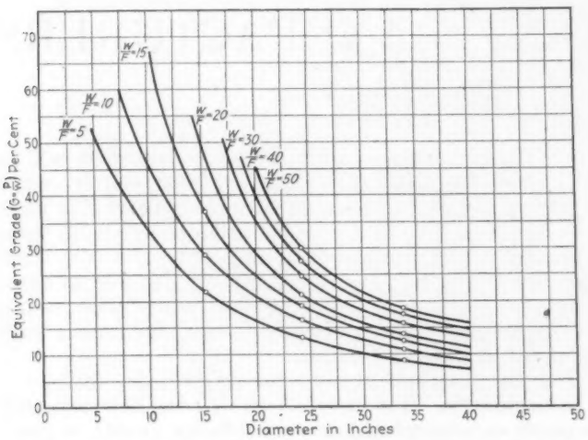


FIG. 12—RELATIONS OF EQUIVALENT GRADE AND WHEEL DIAMETERS Speed 205 ft. per min. Various weights per inch of tire face (W/F)

At the present time this possibility does not seem as remote as does the mathematical expression of n in terms of diameter and load.

AUTHOR'S CONCLUSION

All tests to date have been conducted on the same soil in approximately the same condition. There are unavoidable differences between readings, which necessitate averaging the results from several runs or taking the data from intersections of mean lines in the manner already described. The results from the spading done by no two men will agree, and the same man cannot often check himself. But nevertheless the author feels that the proof of the laws which exist between the quantities involved will be of the utmost assistance when supplemented by such actual field data as can be made universally applicable to the needs of engineers.

THE DISCUSSION

(Discussion contributed after adjournment.)

E. F. NORELIUS:—Investigations of this kind will be of considerable value in enabling tractor engineers to compare results obtained with different methods of drive, without actually making extensive field tests, although it would be necessary to make some preliminary tests.

With a proper foundation, however, it is possible to develop the relations between different functions. In this connection I have had in mind a different manner of analyzing the forces involved. Referring to Fig. 1 of Mr. Moyer's paper and using the same letters, I have assumed that the ground pressure under the wheel must be normal to the surface of the wheel at all times, and that the bearing value (n) of the soil is proportionate to the depression of the soil. To simplify the problem and readily analyze the forces, the half segment bounded by the lines a and d and the circular portion of the wheel may be considered as filled with a liquid, whose density per cubic inch equals n. This liquid will produce pressures on the inside of the rim exactly equivalent to the exterior pressures, and therefore will bear all forces which previously were in the rim when it was in contact with the ground. The value of P will then be equal to the horizontal components of the pressure of the liquid on the rim, which is equal to the pressure of the liquid concentrated on the element d. The unit pressure at the lowest point of the wheel equals dn, therefore,

$$P = \tfrac{1}{2}\, d^2\, Fn \qquad (a)$$

The weight supported by the wheel rim is equal to the weight of the liquid which we have put into the rim, or,

$$W = AFn \qquad (b)$$

where A represents the area of the half segment of the circle below the ground.

In the equations (a) and (b), we have a value of P and of W. The value of P agrees with equation No. 6 of Mr. Moyer's paper, which, as far as the wheel is concerned, is dependent upon the depth of depression and the face, and which we readily can see is correct, as the work done with a certain depth of depression of the wheel, with certain ground conditions, is dependent entirely upon how fast we travel ahead. From the above, we can determine a value of G or equivalent grade:

$$G = P/W = \frac{d^2}{2A} \qquad (c)$$

I have not had the opportunity to check the above value of W and of G with the equation derived by Mr. Moyer. I believe that my analogy in connection with the use of the liquid is correct and gives a very simple method of analyzing the various functions, but I have not had an opportunity to carry this analysis farther at the present time.

A. W. SCARRATT (M. S. A. E.):—The investigation recently carried on by Prof. Moyer is, I believe, along correct lines, and when embodied in simple formulas should prove very useful. These investigations, by all means, should be continued, as the really valuable information is still to be obtained. Future experiments with tractors of known mechanical efficiency should be conducted in the field with a view to determining the coefficients of traction of smooth wheels on various soils and also, in each case, the limit of tractive effort under given soil conditions for wheels equipped with various types of cleats and grouters, when working under loads. The increased resistance to rolling of wheels equipped with cleats or grouters of various forms should also be determined.

An understanding of geology is of great value to both the tractor engineer and salesman in helping them to determine the form of wheel equipment best suited for different kinds of soil. These experiments should be conducted in the open, under the guidance of a committee of engineers, by men paid to devote their time to this work. Even when done in this way considerable time will be required to obtain all of the data. The data would be very valuable to the various universities, and their financial assistance should be solicited.

L. F. SEATON (M. S. A. E.):—Tractors being a comparatively new development in the automotive industry,

little is as yet known of their actual performance under varying conditions. The work conducted recently by Prof. Moyer is another step in the advancement of this new engineering phase. Such work should be encouraged not only because of its scientific importance, but also because of its significance in the future development of the tractor.

I have read the paper by Prof. Moyer with great admiration, partly because of the interesting deductions obtained, but mainly because of its practical importance. In his experiments, Prof. Moyer has shown conclusively that the resistance between wheels and the soil increases with velocity, the rate of increase being somewhat more rapid with heavy loads than with light loads. Lines plotted to represent the relation of speed to the resistances, for weighted wheels under varying conditions were shown to intersect at a point of zero resistance and a speed (expressed in revolutions per minute), of a definite negative quantity for all wheels. Of course it is difficult to comprehend the full meaning of such results. Whether they actually represent practical data or merely hypothetical results that may be verified mathematically is as yet to be determined. That the bearing value of the soil is dependent upon the speed and diameter of a wheel was another interesting result verified by these investigations.

LICENSING FARM IMPLEMENT MANUFACTURERS

IN response to an inquiry requesting information in regard to the licensing of the farm equipment industry, under the recent proclamation of the President, Secretary Houston of the Department of Agriculture, charged with the administration of the regulations, has written that "every effort will be made to assure to farmers an adequate and continuous supply of farm machinery and equipment at reasonable costs, to assist manufacturers in securing the requisite quantity of raw materials, to facilitate the shipment of these materials to the manufacturers and of the finished products to the distributors and to farmers, and to correct any abuses that may exist which the food-control act gives power to deal with."

Abstracts from Secretary Houston's letter are quoted below:

"There is evidently much disturbance among the farmers of the nation over the matter. Many representations are made that the prices of farm machinery are unduly high. Others are made that difficulties are experienced in securing certain kinds of machinery within a reasonable time. Clearly, there are many questions that can be determined only by impartial authority, and it seems highly wise in the present situation that all matters of such interest should be considered formally by the Government, and not only that all abuses, if any exist, should be corrected, but that all proper assistance should be furnished to all parties in carrying on their legitimate enterprises under as favorable circumstances as possible.

Reasons for License

"Partly for the reasons indicated, the farm machinery industry, like a number of other industries of the nation, is being placed under license under the terms of the act commonly known as the food-control act, which was approved on August 10, 1917. Section 5 of that act is the licensing section, and its language indicates the purpose in mind. As indicated, the President is authorized to issue licenses and prescribe regulations.

Provision for Penalties

"This section also provides proper penalties. It will be the aim of the authorities handling this matter, while protecting the consumers against any unreasonable practices, or against profiteering and attempting to aid them in securing their equipment at fair prices, to deal absolutely fairly and justly with the industry, and to assist it in any proper way in securing the requisite materials and the necessary transportation, and in promoting such economies as may be feasible.

"The law does not provide for direct price fixing for farm machinery. It is unquestionably true, however, that the power to prevent unfair commissions, profits or practices may indirectly materially affect prices.

"The food-control act expressly exempts retailers as such from the licensing requirements, and defines a retailer as 'a person, copartnership, firm, corporation or association not engaging in the wholesale business whose gross sales do not exceed $100,000 per annum.' However, under the provisions of the food-control act, retailers will not be allowed to profiteer; under the regulations issued with the President's proclamation retailers engaging in such practice will not be able to secure a supply of farm equipment.

Restrictions Upon Sales

"The regulations provide that a licensee shall not, without the express sanction of the Secretary of Agriculture, sell any farm equipment to any person engaged in the business of selling or utilizing such equipment if the licensee has knowledge that such person, after the regulations became effective, has violated the provisions of the food-control act by making an unjust or unreasonable rate or charge in selling or otherwise handling or dealing in such equipment or by holding, contracting for, or arranging for a quantity in excess of the reasonable requirements of his business for use or sale by him for a reasonable time."

SIDE GUIDE & GRIPPER

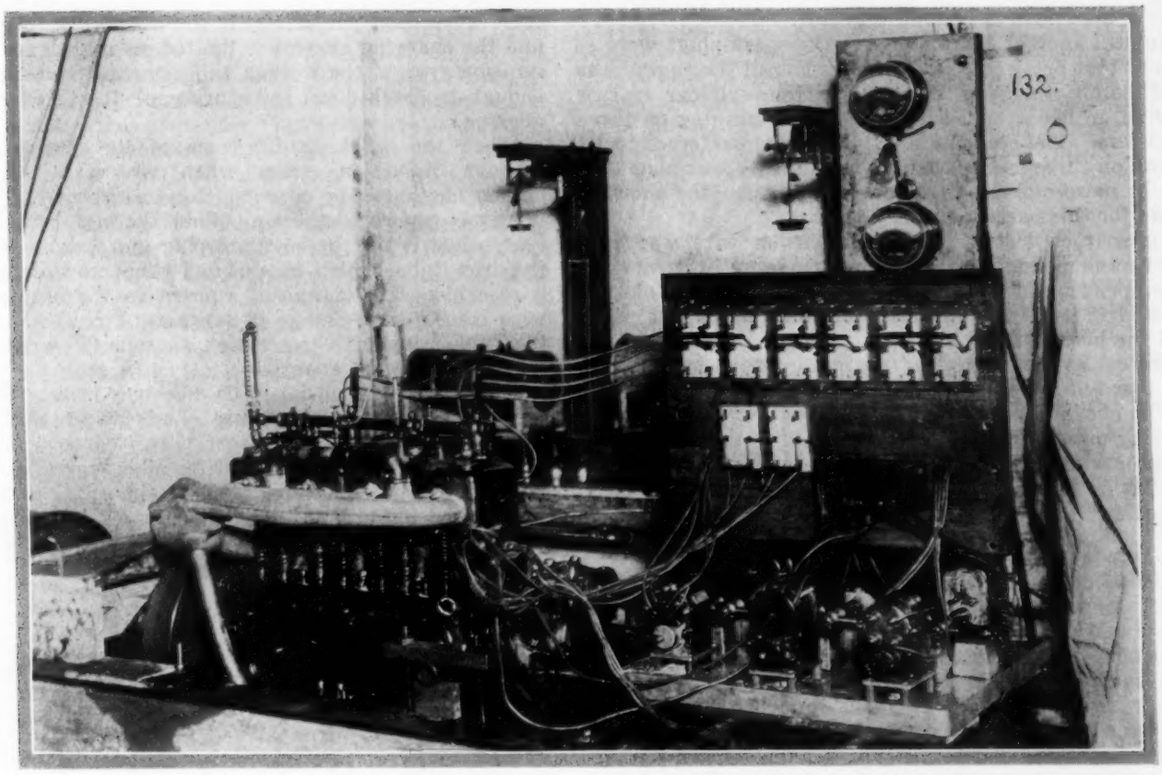


Fig. 1—Apparatus used in Testing Six Makes of Magnetos. All Driven by the Same Camshaft

Magneto Ignition for Farm Tractors

By J. G. ZIMMERMAN* (*Member of the Society*)

MID-WEST SECTION PAPER *Illustrated with* PHOTOGRAPH AND CHARTS

THERE is much evidence in the various tractor products now marketed to show that not enough care is being exercised in installing ignition systems. The tractor engine has different conditions to meet than has the automobile engine, and as a consequence, certain requirements must be more positively met. The object of this paper is to bring out several matters of importance pertaining to the proper installation of magnetos and to the principles underlying their construction.

In the tractor engine we have what is known as constant duty work—the engine is worked hard and at high load-factor most of the time; consequently, all appliances and accessories are subjected to harder service than in the automobile. This means then that such accessories must be well constructed mechanically and made so that proper attention may be given to keep them in order. It means also that the appliances must be conveniently located and well protected.

Not long ago a tractor manufacturer pointed out with pride his method of fully enclosing an engine and gearbox. I noticed with particular interest that the only unprotected part of his equipment was the magneto. It was placed where a single accidental blow could readily put the entire outfit out of commission. It was also placed where dust and dirt could collect in quantity. This particular tractor now is provided with better protection for this magneto, in accordance with suggestions I made.

Upon examining the installation in a truck engine, I found the magneto crowded into a corner under the dash with the breaker-box toward the rear. It was almost impossible to get one's hand through the available space to get at the breaker-box and absolutely impossible to adjust anything without first completely removing the magneto itself. Such an installation leads to poor service.

Another case in point was a tractor engine on which the magneto was placed where it would defy anyone to attempt to get at it if the engine were hot and trouble developed, as one would have to put his arm through a

*Service Manager, Sumter Electrical Company.

SIDE GUIDE & GRIPPER

loop in the exhaust pipe to touch it. Because of this location the magneto became very hot.

In still another tractor engine the spark-plugs were so placed that one would prefer to wait until the engine was cold before touching them. One four-cylinder tractor engine, in use at a tractor school, was running on three cylinders. The students and instructors preferred to let it run on three rather than fix the faulty spark-plug. As ten or more makes of tractors were in use, the showing made for this particular one was poor.

In another instance the high-tension wire was sent out by the magneto manufacturer made up in harness or of proper lengths to suit the installation. The person who applied it used the shortest cable for the longest reach and the longest for the shortest, with the result that the short cables rested tightly on one cylinder head, while the rest fell loosely over the engine.

The above illustrations show that either the engineers putting out the equipment do not realize the importance of proper installation or they are negligent. At any rate, it is timely to call attention to the faults and their remedies.

By Way of Education

Let us consider the engine fuel charge and its ignition. Much has been said but relatively little done to determine what constitutes good ignition. I cannot conceive of a charge of gasoline and air at a given temperature and pressure requiring more heat or a higher voltage or any different spark for a small engine than for a large one. The gas charges being identical, except as to volume, it appears to me that the same spark will ignite either charge with equal facility. For a given charge the spark must be sufficient, that is, of proper voltage and of proper heat value. By proper heat value is meant a sufficiently high rate of heat generation at the igniter device to inflame the charge so that it will give the best power stroke.

The timing of an ignition system is a matter of a small fraction of a second. Thus a 1200 r.p.m. engine, in which the ignition occurs during 0.050 sec., will lose about 7 deg. in timing if the ignition is 0.001 second late. The modern magneto furnishes a spark that occurs under accurate timing conditions. All magnetos are tested at the factory for such accuracy, and a variation of ½ deg. is rare.

Principles Involved in Wiring

The wiring of any ignition system has a great deal to do with its performance. Poor wiring can put the best source of ignition out of synchronism with the engine. A case of this kind was found at a marine engine company's plant. Here the magneto was all right but part of the wiring was run through a metal tube for 4 ft. or more. The tube being grounded and the wire being located inside of it, energy was lost sufficient to make the sparks fail and also to be late when they did pass across the gaps.

In order to understand the loss of energy just referred to, it is well to explain how it occurs. When two conductors are parallel and near to each other but separated by air or some material like glass, a condenser is formed. The larger the surface and the more nearly they are brought together without touching, the greater will be the size or capacity of the condenser. If the high-tension wire is charged positively from the magneto, the grounded tube becomes oppositely (negatively) charged. The larger the condenser, the larger will be the charge that it can take at the same voltage, and also the longer it will take to charge it when supplied from a constant potential. If the capacity is very large and the charging current is limited, as is the case in any ignition system, the voltage will not rise to a value high enough to break down the spark-gap. It will then cause missing.

When the spark occurs some of its energy is lost through induction, since when we vary the magnetism surrounding a conductor, a current of electricity is generated therein. Thus the high-tension current, when it jumps the spark-plug gap, passes through the iron tube, which is a closed conductor around the wire cable. The charge of current in the high-tension wire results in a change of magnetic flux about and in the tube, causing a generation therein of current and therefore a loss of energy.

The remedy is obvious—do not use metal tubes to carry the high-tension wires. Long wires take more time to be charged than short wires, consequently the ideal consists of the shortest possible wires of equal length from the ignition device to the spark-plugs. A wire placed too near the engine increases its capacity to become charged. Hence all wires should be kept at least 1 in. from grounded or other metallic parts. Likewise, all wires should be kept at least ½ in. apart and not all be run in the same tube, even though it be nonmetallic.

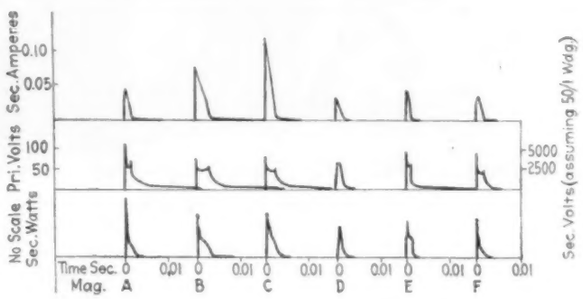


Fig. 2—Output Wave Forms of Various Types of Magnetos
Magneto speed 300 r.p.m. Watts are compared on the basis of like primary-secondary turn ratios

Spark Requirements

In order to understand the importance of proper wiring, let us next consider the character of a spark. Inasmuch as the period of inflammation of a gas charge is short (at 1200 r.p.m., ignition 30 deg. early, exhaust valves open 40 deg. before lower dead-center, it is 0.0236 sec.), the instant of ignition is important. It must be definite and not subject to variation; it must occur exactly when wanted and ignition should occur at a time definitely relative thereto, that is, the inflammation should start at some exact positive period after the spark starts. Hence, all ignition systems must be so designed that this will be effected. Fig. 2 shows a set of spark characteristics taken from several different makes of magnetos for rough comparison. Owing to the difficulty of measuring the spark (secondary) voltage of high-tension apparatus, we have taken advantage of the transformer relation of primary to secondary currents. If we measure the primary voltage and secondary current, we can, knowing the ratio of turns, approximate the secondary circuit characteristics. We hope, however, sooner or later to obtain the true secondary voltage characteristics; we are working along this line with some prospects of success.

From Fig. 2 we see that all types of magnetos act

about the same way, save for the differences in values of voltage and current. The watts calculated from the other data are not expressed in relative terms, and, although one magneto appears to outclass another, it may not in actual performance, since no definite data as to winding ratios are at hand. The curves are intended to illustrate only the above-mentioned facts.

In Fig. 3 is shown a set of oscillograph records, which illustrate an important fact. The records are those of a magneto running at constant speed and having the secondary spark gap of needle points in air varied from short circuit to a gap too large for the voltage to jump. The secondary currents gradually increase as the gap is reduced from the open-circuit to short-circuit position; at the latter the current, instead of following the jump spark, is generated as the rotor changes the flux through the coil.

At open circuit, the current being zero, there is no energy available at the gap; likewise at short circuit there is none available there. Hence somewhere between the two extremes there is a gap where maximum energy will be developed.

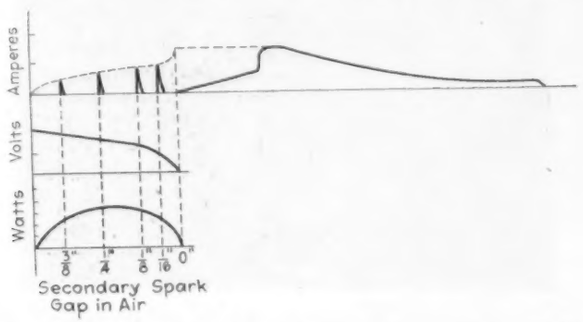


FIG. 3—OSCILLOGRAPH RECORDS OF SECONDARY CURRENTS AND VOLTS WITH VARIABLE SPARK GAP

Maximum energy at gap of 0.25 in. in air, or about 0.04 in. under compression at 90 lb. per sq. in.

In this particular case the maximum is close to 0.25 inch. As this test is made in the open air, at one atmosphere, and, since with a given voltage, the gap that will be jumped decreases as the absolute pressure is increased; the gap corresponding to the 0.25 in. between needle points in air will be one-sixth of 0.25 or 0.04 in. at 90 lb. compression pressure, or about six atmospheres. Now, since the voltage required to send a spark a given distance through air increases when the spark gap terminals are changed from sharp points or edges to rounded surfaces, the 0.04 in. is further reduced, say, to 0.03 inch.

This explains why manufacturers recommend a gap of from 20 to 30 thousandths of an inch for their magnetos, as the best results are then secured. All magnetos are intentionally designed to generate about the same voltage under like conditions, although not always made to do so.

Initial Kick Voltage

Particular notice should be taken of the first voltage kick of the primary, which corresponds well to that of the secondary. This is true since the voltage developed by coils of wire over the same core must of necessity develop the same voltage per turn. This initial kick starts the spark. Needless to say, anything which chokes or holds back this kick lowers the efficiency of the spark. Hence the importance of the foregoing information regarding wiring; its influence on the spark effectiveness is apparent. Note that the voltage kick is almost instantaneous. This means that it is decidedly preferable to have the charging of the high-tension cable circuit instantaneous. Long cables, metal tubes for guiding them, and cables near ground or each other, and hot insulation are all undesirable.

Energy of the Spark

The initial or "kick" voltage is not responsible for the whole spark, nor is it the only factor controlling ignition. Ignition is effected by the heat of the spark and the "follow-up" current of the spark does the heating or inflaming. Hence, we must have first a good "kick" voltage and then one that will secure a proper follow-up current.

The follow-up current must follow closely the breakdown or kick voltage. If the spark has a certain total heat value it may or may not properly ignite the charge of gas. That depends upon the rate at which this energy is dissipated. If protracted over a long period the rate is low—if over a short period, the rate is high. Evidently, if the rate is high and the energy dissipated sufficient to heat the surrounding gas to an ignition temperature, the ignition approaches an instantaneous character. The essentials, therefore, of a good spark are, first, a good kick voltage high enough to break down the spark gap, and then a rapid follow-up current of sufficient heat value to ignite the charge right on the heels of the breakdown across the gap.

Some magnetos have a lower kick voltage than others and a heavy protracted follow-up current, dragging out the current for 30 deg. or more after the spark voltage breaks down the gap. Obviously this is too long and it would be preferable to concentrate the heat over a shorter period at a higher rate. Such magnetos suffice for low compressions and low-grade fuels, but are poor "starters" at low speeds.

Often the users of some makes of magnetos wonder at the "pep" of the spark in starting. This is because of the fact that the spark energy is quickly dissipated and not dragged out. The oscillograph has difficulty picturing the spark because of this fact. Recent tests with an especially sensitive oscillograph vibrator showed a surprising initial voltage, which accounts for the effective spark with the accompanying concentrated current.

Tests made with a four-cylinder engine running on kerosene showed that most magnetos on the market meet the requirements of good ignition. Fig. 1 represents a test of six makes of magnetos driven by the same camshaft. Each magneto was given its own advantageous spark advance and in the test not one magneto developed the slightest difference in output. Any magneto could be thrown on at any moment, so that during the test the fuel, carbureter, load, spark-plugs, cables and water temperature were identical.

It was particularly noted on examining the timing that all systems employ almost exactly the same advance, that is, the first part of the spark does the work. With the magnetos delivering large or long-lasting sparks the charge was fired at the beginning before the whole spark was developed—proving that the follow-up was not necessary.

MAGNETO MAKE-AND-BREAK SPARKS

It must not be construed from the above remarks about the concentrated follow-up current, that a small follow-up will always suffice. In the use of low-grade

fuels, a spark of longer duration will undoubtedly help to insure good ignition although it may be perhaps a little irregular. Hence, low-speed engines using fuel oil or low-grade kerosene are preferably ignited by a "fat" spark. The make-and-break ignition system is here preferable because the energy of the spark is greater than in high-tension systems, and the fouling of a plug or igniter is less apt to occur. In the high-tension systems the voltage over the insulation is from 2500 to 4000 volts or more, depending on the compression temperature and spark gap, while in make-and-break systems it seldom exceeds 250 volts.

Fig. 4 shows the spark energy of a small "plug oscillator," which is a combination in one unit of a magneto and make-and-break mechanism, for one-cylinder engines only. The spark output of this is much greater than that of the largest standard high-tension magneto in use today. Now that we are forced to use low-grade fuels there is no reason why the make-and-break system should not prove as satisfactory as high-tension ignition on low-speed, single-cylinder traction engines. In the case of small farm engines, "plug oscillators" are proving a great advance over the older battery systems. One reason lies in the efficiency and mechanical durability. Another is the fact that with such a device the spark may be readily

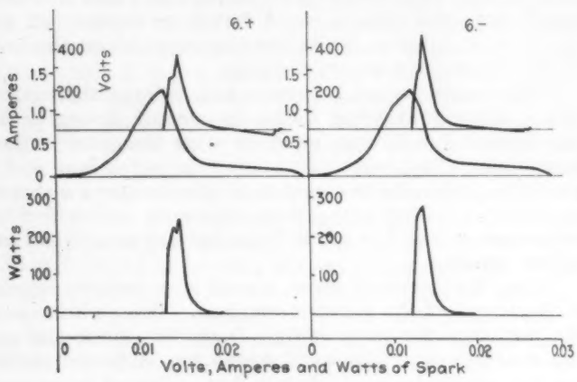


Fig. 4—Spark Energy of Small "Plug Oscillator"

tested at any time to prove its condition. It also can be cleaned readily. It is possible, therefore, that low-tension ignition may come into more extended use for tractors with single-cylinder low-speed engines.

We have successfully run "plug oscillators" at 1200 r.p.m., which is from two to three times normal speed and is not feasible for regular use.

High-Tension Voltage and Starting

It is well known that the magneto develops a weaker spark with reduced speed and that at very low speeds (below 50 r.p.m.) it is very difficult to start an engine on the magneto. As tractor engines are usually heavy and hard to crank, starting is difficult without some means to help to give a satisfactory starting spark. In the battery and coil system a separate battery is required, as is also a separate high tension vibrator coil or a magneto coil with a master vibrator.

Fig. 5 shows the battery-coil system applied to a magneto. The sparks are all satisfactory. The user must remember to turn the switch over to "straight magneto" when the engine comes up to speed. Unless some extra automatic device is used with it, he usually forgets and finds that the next time he wants to start, the battery is "dead."

Starter Coupling with Magneto

The starter coupling is a simple mechanical self-contained automatic or semi-automatic attachment to a magneto by means of which the operator, after priming the engine, can crank it at any speed desired, when it will deliver a fine spark. After the engine is started, the de-

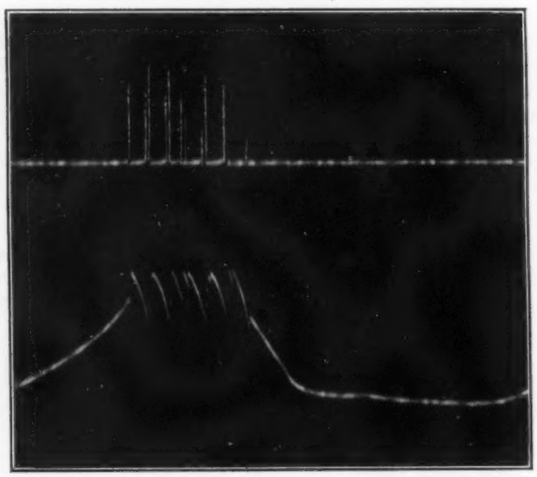


Fig. 5—Results with Battery-Coil System Applied to a Magneto

vice is cut out and the engine run on the magneto alone. The semi-automatic outfit is preferable because it is seldom necessary to run a tractor engine below 100 r.p.m. For mechanical reasons the device is not suitable for continuous service, its object being to start the engine.

Fig. 6 shows the advantage of the starter coupling

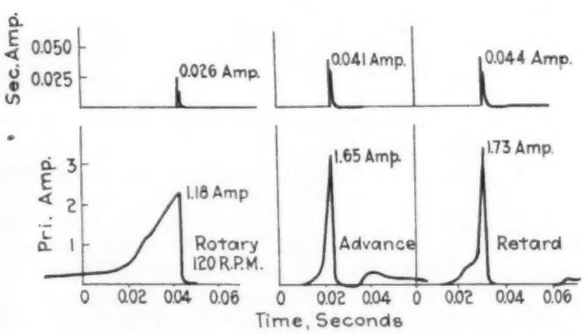


Fig. 6—Records Showing the Magneto Operation with Starter Coupling and with Rotary Action

over straight rotary action. Here with the magneto operated at 120 r.p.m. the spark energy is less than half that obtained with the coupling. Any properly designed starter coupling should retard the spark, no matter where the advance lever may be located. The starter coupling, if used, insures greater safety to the operator. Fig. 7 shows the action of a starter coupling from start to throw out.

Location of Magnetos

Several tractor manufacturers place the magneto not only in an inaccessible, but also in a hot place. As a general rule the higher the temperature the poorer an

electrical insulator becomes. Hence, the effect of heat on the insulation of a magneto is to reduce its efficiency. In the future a determined effort should be made to consider the magneto and its location.

In conclusion I wish, therefore, to make a plea for giving the matter of ignition equipment more attention. Most complaints that come to the manufacturers result from either improper installation, making it impossible for the user to give proper attention; or improper attention, owing to lack of information on the part of the user.

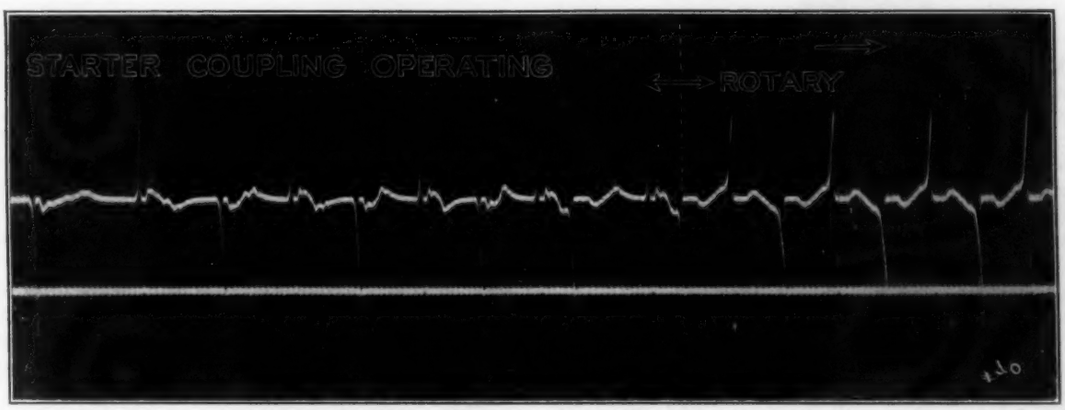


FIG. 7—RECORD OF OPERATION WITH A STARTER COUPLING

This is one reason that so much in tractor ignition satisfaction depends upon service—*reasonable* service under direct factory supervision and available to users on reasonably short notice.

THE DISCUSSION

DARWIN S. HATCH (M. S. A. E.):—What difference in the spark is caused by change of polarity?

MR. ZIMMERMAN:—The material composing the spark arc comes from the electrode and is converted into a vapor by the heat from the electric current. Although it is sometimes thought that this vapor is furnished by the negative electrode, it is in reality furnished by the positive. This fact is evident when a moving electrode furnishes the arc material, as the characteristics of the spark, when the hotter electrode is rotated from the stationary electrode point, are different from those of a spark produced with the cooler electrode as the rotating member. In the latter case the vapor cannot be produced as rapidly.

In airplane engines operating at very high speeds, the cooling of the spark-plug is a very important factor, for if the spark energy is great the point may become hot enough to preignite the fuel.

O. W. A. OETTING (M. S. A. E.):—As with magnetos, it is equally true of all other electrical equipment that it is thought of last. The sooner engineers agree upon the correct application of electrical equipment to tractors and trucks, the better it will be for all concerned. The majority of automobiles now employ the battery system, although some still use the dual system, starting on the battery.

CHAIRMAN G. W. SMITH (M. S. A. E.):—Does each of these plug-oscillators supply a separate cylinder?

MR. ZIMMERMAN:—Yes. The combination of the magneto and the spark-plug constitutes a unit not requiring any adjustments whatsoever. The points are the only parts to be changed and they last a long time.

CHAIRMAN SMITH:—Is the winding duplex?

MR. ZIMMERMAN:—It is a single plain winding; this form of ignition is extremely simple.

CHAIRMAN SMITH:—How does its cost compare with that of the ordinary magneto?

MR. ZIMMERMAN:—About as 15 to 45.

CHAIRMAN SMITH:—Then in a four-cylinder engine it would be as 60 to 45?

MR. ZIMMERMAN:—Yes.

CHAIRMAN SMITH:—I recall a case where metallic tubes eliminated difficulty that had been experienced with fiber tubes.

MR. ZIMMERMAN:—Such trouble might be caused by the fiber being wet, but I believe it more likely that the explanation is to be found in some other factor than the material of which the tube is made.

A MEMBER:—What is the ideal spark point?

MR. ZIMMERMAN:—I wrote a paper on that subject for the January, 1915, issue of the *Gas Review* outlining the characteristics of different spark-plugs and the type I recommended at that time as the ideal spark-plug has two concentric terminals with sharp edges. That type is now being employed in airplanes.

Shock Absorbers for Easy Riding

By MARK H. LANDIS* (*Associate Member*)

PENNSYLVANIA SECTION PAPER *Illustrated with* PHOTOGRAPHS AND CHARTS

THE various elements that affect easy riding of an automobile were discussed during the past winter by the Pennsylvania Section of the Society. Springs, tires and cushions were treated in considerable detail, and the conclusions reached have imparted some new light on those subjects.

We believe the best way to introduce the present subject is to review the conclusions reached by the Pennsylvania Section, after a discussion of the paper† on spring design.

The conclusions of this meeting were, that in order to provide the ideal spring suspension we must have a spring with as low a rate as possible, that is, a "soft" spring, with adequate means for checking its recoil movement without interfering with its compression and without tending to stiffen the spring. Interleaf spring friction was considered undesirable owing to the fact that the damping effects are much less during the recoil movement than they are during the compression movement of a spring. With the friction increased, the rate of a spring naturally must be increased, reducing its shock-absorbing powers.

It was, further, the sense of that meeting that a spring must compress rapidly to absorb road shocks as encountered and it was deemed necessary to control the spring recoil by means of some auxiliary aid to enable the spring to function properly and by so doing secure easy riding. From these conclusions it becomes evident that this auxiliary aid must be a shock absorber.

SPRING SUSPENSIONS

Before discussing the general subject of shock absorbers as applied to passenger cars and ambulances, let us consider some of the factors that have influenced the design of spring suspensions as used today. Furthermore, we will consider the various conditions essential to any spring suspension in order to provide a proper shock absorber to function with the spring itself.

In the early days of the industry the primary consideration was the development of a successful engine to propel the "horseless carriage," and little attention was given to the subject of spring suspension. Springs as used by carriage builders were considered adequate.

The first automobiles had limited speed and were of light weight. Their springs were of light, flexible construction which fulfilled the requirements very satisfactorily. As the art developed greater speed was demanded. This necessitated more powerful engines, and consequently heavier weight throughout all parts of cars.

The change in car design compelled the use of heavier and stiffer springs which in turn reduced the comforts of the passengers. The first step toward relief was the use of large pneumatic tires to replace the old cushion tires and pneumatic bicycle tires. This change provided a flexible connection between the source of power and its point of application and effected a wonderful improvement in riding qualities.

Still greater speed created a demand for a lower center of gravity with another change in spring specifications. This change brought out various types of suspensions; however, many objectionable features were apparent in them—some springs were too stiff, while others were too flexible. This condition brought about the first demand for shock absorbers; that is, means for preventing the rough riding which was so common to the early types of cars.

There were other elements which likewise contributed toward riding discomfort, such as rear axles fixed rigidly to the chassis by means of radius rods, which held the axle and spring at a fixed position, all spring recoils acting in one direction—directly upward. With a rigid rear axle, the car was always started forward with the tire constituting the only flexible connection between the source of power and its point of application. The folly of this design is now appreciated and practically all automobiles now drive through the springs. The springs thus have more freedom of action, improving riding conditions and reducing tire bills.

Unsprung Weight Should Be Minimized

The desirability of reducing the unsprung weight to the minimum has likewise become a recognized fact. The chassis is the anvil to take the blows as given by the axles or unsprung weight through the spring. The axle or unsprung weight is the hammer. The heavier the anvil in proportion to the weight of the hammer, the smaller will be the shocks to the car and its occupants.

The use of special alloy steels and aluminum has greatly reduced car weights. However, the fact that the unsprung weight percentage should be as small a value as possible should not be overlooked.

The unsprung weight has been greatly reduced by the now almost universal practice of making the transmission a part of the powerplant, the use of wire wheels and special alloy steels in axles.

Attributes of Ideal Leaf Spring

If we were to discuss the merits of the different spring types, namely, full elliptic, half elliptic, platform, cantilever, etc., we would ultimately come to the conclusion that, whatever type of spring we thought the best, that type must conform to the specifications of the ideal leaf spring: one having such resilient qualities that it responds to and absorbs the slightest shocks and at the same time is of such strength and range of movement that it absorbs maximum shocks.

*General manager, Landis Engineering and Mfg. Company.

†Spring Design for Easy Riding, by Walter C. Keys, published in the December, 1917, issue of THE JOURNAL.

A car in motion tends to continue in a straight line unless acted upon by an impressed force, caused by the wheels meeting a hole, rut or bump in the road. This impressed force is absorbed by compressing the spring against the force produced by the car traveling in a straight line, the latter force being proportional to the speed of the car and its weight and load. As the impressed force is determined by the unsprung weight, the smaller the unsprung weight the less will be the force tending to compress the springs or the smaller the shock. It is self-evident that with a low unsprung weight a low rate is possible for the spring, that is, a "softer" spring may be employed.

Action and Reaction

For every action there is an equal and contrary reaction. The action in this case is the result of the shock received by the wheel. While the shock is being absorbed by the spring against the car as a fulcrum, the car will move upward without an unpleasant shock to the occupants. Now, if the spring which has absorbed the shock be unrestrained as regards the force of the reaction, the reaction will cause the spring to recoil violently with a force equal to that of the action or shock less that part of the reaction lost in friction between the spring leaves during recoil. This friction is less during recoil than it is during compression, hence the damping effect secured by interleaf friction during recoil is at the expense of flexibility of the spring during compression. The fulcrum for the recoil of the spring is the road, so it is evident that with the car already moving in an upward direction in harmony with the recoil, sufficient momentum in an upward direction is always imparted to pitch the car beyond the normal height of body or chassis as determined by the static deflection of the spring. The

FIG. 1—HELICAL SPRING SHOCK ABSORBER
J. M., Model Z, Twin Tube Type

result is an oscillation of the spring which pitches passengers about and lifts axles and wheels from the road. The lifting of the wheels reduces the adhesion between tires and road. Sometimes this adhesion is entirely destroyed allowing the rear or driving wheels to increase in speed beyond that corresponding to the forward motion of the car. When the tire again grips the road it abrades or rips the rubber from the tread, greatly reducing mileage and life of tires.

The multileaf spring has been offered as the solution of the spring suspension problem, interleaf spring friction being supposed to produce a slow-moving spring that will absorb shocks to such an extent that the reaction will be reduced to the minimum. If sufficient compression friction is introduced the spring approaches the condition of a rigid connection between the chassis and axle,

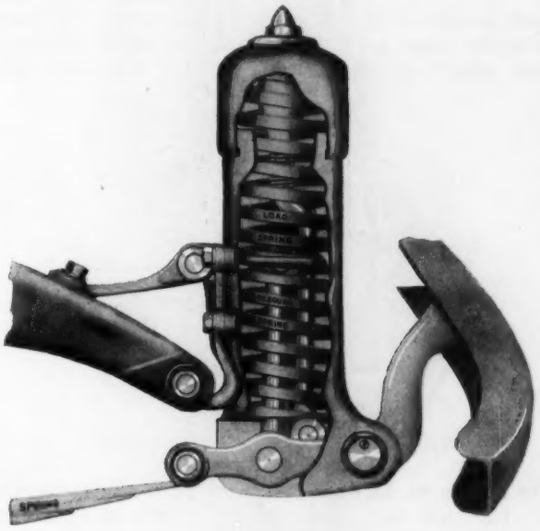


FIG. 2—HELICAL SPRING SHOCK ABSORBER WITH RECOIL SPRING
U. S. E. Type Combined with Bumper

in that case the ability of the springs to act as sensitive shock absorbers is destroyed and reliance must be placed on the tires to do the work of the springs.

Tires Shock Absorbers for Unsprung Weight

The only functions of tires should be to provide elastic connection between the source of power and the point of application and to act as shock absorbers for the unsprung weight of the car; that is, to reduce the pounding action between the road and axles or unsprung weight. That fact is being recognized today by engineers in the adoption of 8, 10 and 12-in. pneumatic tires for trucks. The extra tire cost is more than saved by the reduction in repair bills.

The effects of faulty spring design have been overlooked owing to the fact that deep upholstery has helped to hide the omissions of the spring engineers. However. added comfort will not provide safety and economy.

At times there is a tendency for a car to leap while running over fairly smooth roads. This leaping is caused by the spring being too resilient during its recoil movements. All leaf springs such as are universally used have considerable interleaf friction. Physical tests show that there is more friction during compression than during recoil; the hysteresis effect reduces the flexibility and consequently the quality of the spring during compression, to a much greater extent than it reduces the spring resiliency during expansion or recoil. The spring without the interleaf friction should be of sufficient strength to carry the static load.

The negative force or friction acts as an additional impressed force to be absorbed, that is, the shock plus friction represents the force that tends to throw the car

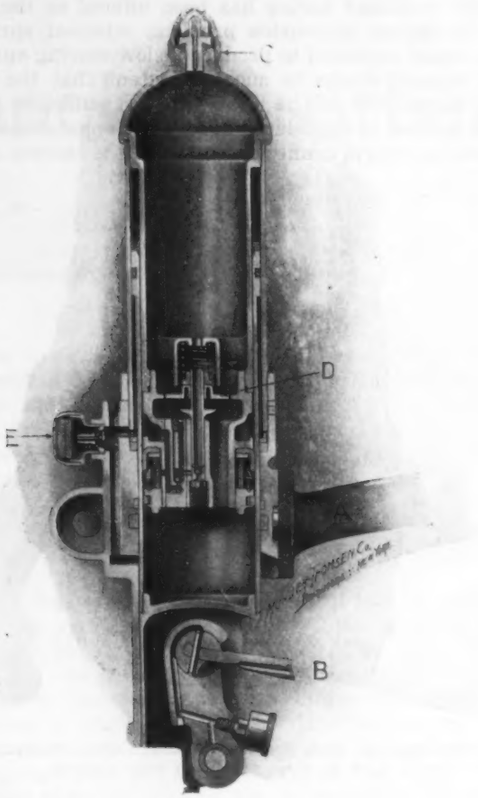


FIG. 3—WESTINGHOUSE AIR SPRING SHOCK ABSORBER

out of its straight line while the shock is being absorbed. When the spring expands, the interleaf friction is much less, and the expansion or recoil is also much more free than it would be if the spring friction were balanced. So it is seen that the combined action of the compression and expansion of the spring, with a much greater interleaf friction or resistance to its action during compression than during expansion or recoil, starts the car leaping, as both actions of the spring tend to pitch the car upward.

Half-Elliptic Front Springs Predominate

The front springs of 95 per cent of the automobiles are of the half-elliptic type with a comparatively small range of movement and correspondingly high rate. The front springs are made this way owing to the fact that they are the first to meet the shock. The ideal spring for the front of a car should have such range and flexibility that it will absorb the entire shock given to the spring, with range of movement sufficiently great to allow the car to travel in a straight line. If the front springs are of short range of movement, the rate of spring will naturally be high and the springs will lack the capacity to absorb the little jolts and jars of the average road. If a car with short-range front springs, traveling at a high rate of speed, strikes an obstruction in the road, the spring may be completely collapsed during the compression forcing the car out of its course in an upward leap. If the shock-absorbing capacity of the springs is taken up, the tires must naturally be called upon to complete the absorption of the shock. If the rear springs were designed like the average front springs of an automobile, there would not be enough tire manufacturers to provide the trade with tires.

Causes of Skidding

The front wheels of any automobile should be in contact with the road at all times, for the instant the wheels leave the road, the driver is at the mercy of the rear wheels. The adhesion of the front wheels to the road is to an automobile what the wheel flanges are to a locomotive running on a steel rail. When the front wheel loses its grip on the road the fulcrum by which the car is steered is destroyed.

Such freaks of an automobile as "skidding" and "turning turtle" are directly attributable to the loss of the adhesion between the wheels and road, one of the driving wheels losing its grip on the road owing to excessive spring recoil or slippery spot in the road. With the engine pulling and only one wheel gripping the road, the speed of the wheel that lost its grip is suddenly increased. Assuming that the wheel with increased speed suddenly takes hold, and the other wheel starts to slide, the high-speed wheel will suddenly sway the car to the opposite side. If at this particular instant the front wheels have not sufficient grip on the road to overcome the sway, the momentum of the rear end of the car will cause it to whirl around. If the rear wheel meets an obstruction sufficiently large to suddenly stop this skidding, the car will "turn turtle."

SUMMARY OF SPRING DESIGN

We believe that the first essential to easy riding of any automobile is the employment of the ideal spring suspension, provided with adequate means for controlling its objectionable features, without in any way interfering with its good qualities.

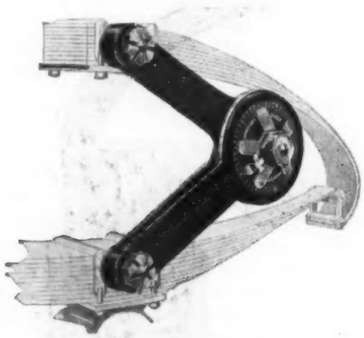


FIG. 4—HARTFORD SLIDING FRICTION SHOCK ABSORBER

The design of an ideal spring suspension involves the following factors:

1. Flexibility of spring mounting.
2. Light weight of car.
3. Low percentage of unsprung weight.
4. Low spring rates.
5. Large range of spring movement.
6. Elimination of interleaf spring friction.
7. Increase of front spring range.
8. Adequate means for control of spring recoils.

We fully believe that if a concerted effort along these general lines is made by the engineers of the automobile industry, a spring suspension far superior to anything produced up to this time can be developed.

Personally, I do not consider an auxiliary aid that controls spring recoils a "shock absorber." The spring itself must be the shock absorber. However, since auxiliary springs and other supplementary devices have become known as shock absorbers, we will use this term in describing all such devices.

Shock Absorber Classification

We would classify shock absorbers under the following headings:

1.—Auxiliary spring.
   (A) Helical.
   (B) Air.
2.—Compression and recoil-damping.
   (A) Sliding friction.
   (B) Flat spring.
   (C) Hydraulic friction.
3.—Recoil-damping.
   (A) Recoil strap.
   (B) Sliding friction.
   (C) Hydraulic-pneumatic friction.
   (D) Hydraulic friction.

When we first found that automobiles needed some auxiliary means to provide greater comfort in travel we sought relief from stiff springs in the use of auxiliary spring shock absorbers. The auxiliary spring shock absorber "ironed out" the little irregularities in the roads and greatly improved riding conditions, especially at moderate speeds.

However, at higher speeds springs "hit bottom," producing a pounding of the chassis on the axle accompanied by violent recoils. To eliminate this we resorted to the

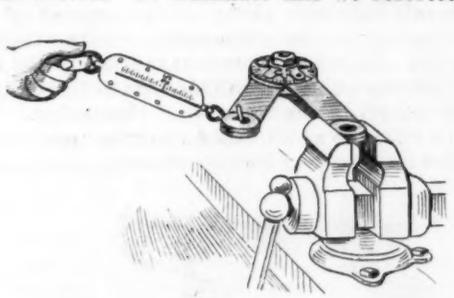


Fig. 5—Adjusting the Sliding Friction Type for Constant Friction

two-way or compression and recoil-damping type of shock absorber.

It next became apparent that we might control violent spring actions by checking only the recoil movement of the spring. This brought into use the recoil-damping type of shock absorber.

Auxiliary Spring Shock Absorbers

Helical Spring Types

The use of the helical spring as a shock absorber makes it possible to correct the faults of hard or stiff springs found on many automobiles today.

It is a well-known fact that many automobiles with light loads do not ride smoothly when running at low speeds over moderately good roads. This is due to the fact that their springs have not sufficient range of movement and that they are not sensitive enough to absorb all the little jolts. The springs are made stiff enough to provide for the maximum loading but the range of movement provided in the design makes it impossible to use a lower rate spring.

With a helical spring shock absorber, Fig. 1, interposed between the two halves of the spring or between the ends of the spring and frame, the effective working range of the main and auxiliary springs, as a unit, is greatly increased, making it possible to have an ideal spring in so far as the shock-absorbing qualities of the spring itself are concerned.

However, unless means are provided to control the recoils of this extremely sensitive spring, easy riding conditions will not be provided. Some auxiliary spring

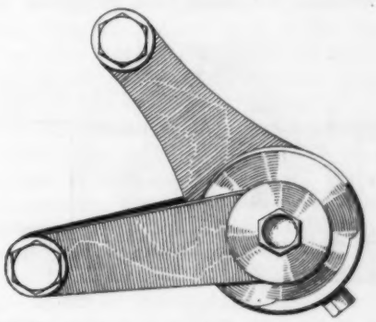


Fig. 6—Connecticut Flat Spring Shock Absorber

shock absorbers provide a recoil spring as a part of the mechanism to arrest the recoils. (See Fig. 2.) This recoil spring, to be really effective, must be so strong that it will kill the softening effect of the loading spring. The auxiliary spring has no influence on the recoil effects of the main spring itself other than to make a compound spring of the two, as each spring has a different period. At times the difference in period would throw the auxiliary and main springs out of phase and at other times, dependent upon the speed and nature of road traveled, the phases would coincide, tending to increase the effect of recoil.

Air Spring Type

The use of the air spring shock absorber, Fig. 3, corrects the faults of a hard or stiff spring in the same manner as the helical spring type. It provides an ideal spring insofar as the shock-absorbing qualities of the spring itself are concerned, as the air spring is interposed between the frame and the end of the main spring. It likewise increases the effective spring range of about six inches, giving very soft, flexible action.

The recoil of the air spring is taken care of in the shock-absorber design. However, means are not provided for controlling the recoil of the leaf spring. The criticism of the helical spring likewise applies to the air spring. The air spring and the leaf spring make a compound spring, each having a different period; the difference in period throws the two springs out of phase at times, and in phase at other times. When the two springs are in phase, the recoil effect is pronounced; however, the intervals between synchronized phases are much longer than would be the case with the average single unit *ideal* leaf spring; in other words, this device produces a soft, flexible spring unit with a long period. The effect of the recoils may become cumulative, and at continued high speeds the spring movement becomes considerable, so that, unless the recoil of this compound spring of long period is controlled, the recoils will be dangerous.

Compression and Recoil-Damping Shock Absorbers

Sliding Friction Type

The sliding friction type of compression and recoil-damping shock absorber was first brought into public use when a remedy was sought to prevent violent spring vibrations, which cause great discomfort in riding.

The effect of "free" and "forced" vibrations causes excessive spring action, making a free soft spring "hit bottom" and then recoil violently. By "free vibration" we mean that vibration which occurs in a spring when it is allowed to expand suddenly after compression. By "forced vibration" we mean that vibration caused by an

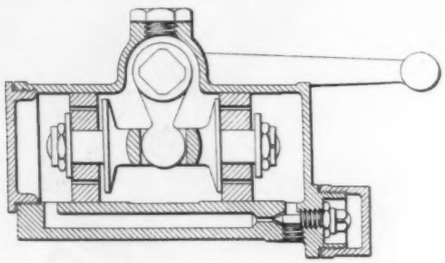


Fig. 7—Renault Hydraulic Shock Absorber

impressed force compressing the spring. If the free and forced vibrations are controlled, the objectionable features of recoil are naturally taken care of.

The sliding friction shock absorber was designed to prevent this excessive spring action. If the spring is not allowed to "hit bottom" the recoil of the spring cannot become excessive; furthermore, when recoil does start, the sliding friction arrests it.

Racing Car Shock Absorbers

This type of shock absorber has been used very largely in the automobile racing cars, but not with the idea of securing easy riding. The purpose is to prevent violent spring actions which, if not properly controlled, make high speeds impossible.

For the racing car, the pneumatic tire is the only spring or shock-absorbing medium used between the car and the road. If we designed springs to absorb all the road shocks and then prevented the recoils we would be able to secure much more mileage on tires of all racing cars. We would likewise secure better traction and higher speeds. As evidence of the fact that racing cars are so designed that they have no springs or shock-absorbing medium other than the tires, on one racing car that during 1917 had an exceptionally successful season, 5-in. tires were used on a 1600-lb car. If that same car had been equipped with 3½-in. tires, the size recommended for a car of this weight, how long would a set have lasted in a race? In order to keep this car going it was necessary to use tires such as would be recommended for a 5000-lb. car.

The main fault of the sliding friction shock absorber is that it interferes with spring compression; in other words, it produces a stiffer spring, which is undesirable. Furthermore, the initial friction, as adjusted for each shock absorber, is a constant at all times, regardless of the speed of spring movements; the resistance is not in proportion to the speed of spring recoils, which is a requisite for every shock absorber or spring recoil controlling device.

Any friction introduced that is a constant, and not a function of the motion during spring recoil, is a negative action working against the real shock-absorbing power of the spring.

Fig. 5 shows the method used for adjusting the friction of the shock absorber. This friction is not a function of the motion of the spring during recoil. This initial friction remains constant whether the recoil is mild or violent.

Flat Spring Type

The flat spring form of shock absorber, Fig. 6, was developed to perform the same functions as the sliding friction type.

Three flat springs, set 120 deg. apart in a casing, are made a part of one arm of the shock absorber and are acted upon and compressed by a triangular cam which rotates on bearings which are a part of the casing. The cam is rigidly connected to the other arm of the shock absorber.

This shock absorber likewise interferes with compression, tending to produce a stiffer spring. However, it does not have any influence on the spring until the spring movements become excessive. As the shock absorber has a neutral point, the effect of working is dependent upon the loading of the car to which it is attached.

Hydraulic Friction Type

The two-way hydraulic shock absorber, Fig. 7, is of the compression and recoil-damping type. It prevents violent spring actions by introducing hydraulic resistance which is in proportion to the speed of spring movements.

It prevents excessive action at the expense of stiffening the spring on the compression stroke, thereby increasing the impressed force transmitted to the chassis. Another serious objection to this type is the difficulty of retaining the oil in the interior of the casing. The device, to be effective at all times, depends upon the casing being filled completely with oil, otherwise the absence of

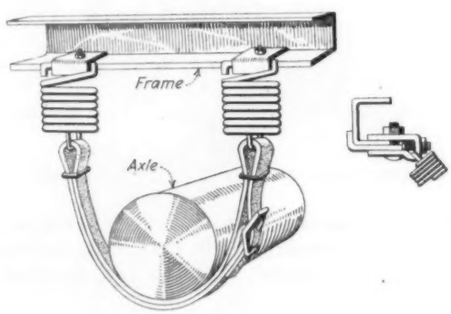


Fig. 8—Mesinger Recoil Strap Shock Absorber

resistance at the start of spring movements results in a slapping action. This device, when working properly, produces the effects of a slow-moving stiff spring.

Recoil-Damping Shock Absorbers

Recoil Strap Type

This recoil strap type, Fig. 8, is a very simple shock absorber, designed to prevent excessive recoils. It does not interfere in any way with the compression of the spring, merely reducing the extent of spring recoils.

It has the great disadvantage, however, of tending to

lift the axle from the road while arresting spring recoils. It may increase riding comfort, but it certainly cannot fail to increase tire wear and make the danger due to skidding excessive.

Sliding Friction Type

The recoil-damping shock absorber of the sliding friction type, Fig. 9, was designed to snub the recoil actions

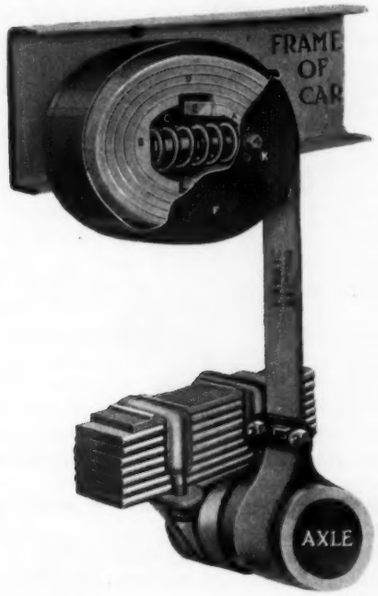


FIG. 9—GABRIEL SNUBBER, OF SLIDING FRICTION TYPE

of a spring. Violent spring recoils are checked when the spring attempts to recoil above the position determined by the static loading of the car.

This device depends on having the strap between the chassis and axle kept under tension at all times. The coil spring acting on the blocks inside of the coiled strap keeps the strap under tension. When the main spring is compressed, the spring coils acting on these blocks follow after and bear against the inside of the strap coil. When recoil starts, the snubbing action tends to arrest the recoil.

This shock absorber tends to interfere with the springs' compression, due to the fact that the springs are harnessed down to provide initial tension on the strap. This has the effect of making the spring stiffer. The greatest objection to this type of absorber is that the resistance to recoil is greatest when the spring has the least reactive resistance. In other words, the recoil is arrested, in fact completed, before the spring reaches its normal position, as determined by the static loading, always leaving the spring rigid at the start of the next compression movement. Furthermore, this device is not self-adjusting, as the snubbing action depends upon the loading of the car, owing to the variation in pressure of the coil springs on the blocks inside the coils. This variation in pressure varies the tension on the strap.

Hydraulic-Pneumatic Friction Type

The shock absorber of the hydraulic-pneumatic friction type, Fig. 10, is so designed that the recoils of the spring are controlled by means of hydraulic-pneumatic resistance. When the spring is compressed, the valve in the piston opens, allowing oil to flow through the piston. When the spring recoils, the valve in the piston closes and the recoil is met by a hydraulic-pneumatic resistance. The air in the space above the oil level is compressed until the pressure corresponds to the resistance offered by the oil in passing through the by-pass holes in the piston. After the air has been fully compressed, the hydraulic resistance starts, producing a gentle recoil of the spring to the height, as determined by the static load, the resistance to recoil being in direct proportion to the speed of spring recoils. If the extent of spring action is slight, the resistance to recoil is slight, as the speed of recoil is a function of resistance; likewise with violent spring recoils the speeds of travel is high, with the resistance directly proportional to the speed. Every spring has a fixed period if allowed to oscillate freely; however, the speed of recoil is directly proportional to the amplitude of the spring, if the period is a constant.

This shock absorber has the disadvantage of using a pneumatic resistance to start the recoil stroke. As air is a compressible medium, there will naturally be an increase in speed of spring recoil at the instant recoil starts. However, after the air has been compressed to a certain pressure, dependent upon the size of by-pass in the piston, the resistance to recoil is directly proportional to the speed of the spring's recoil, as the oil is an incompressible medium.

We believe that the mechanical construction of this device makes it advisable to provide a pneumatic air cushion, in order to prevent a slap or sudden jolt at the start of the spring's recoil.

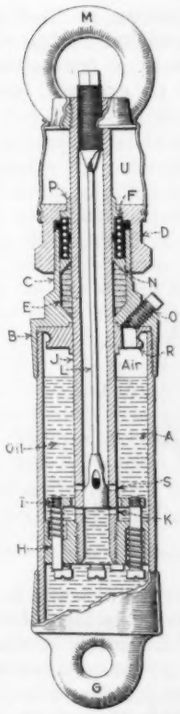


FIG. 10 — FLENTJE HYDRAULIC - PNEUMATIC SHOCK ABSORBER

In a shock absorber of this construction, it is practically impossible to provide an active hydraulic resistance at the instant recoil starts. There is bound to be a cavity above the piston which will permit of a sudden acceleration of the spring at the instant recoil starts. It would be impracticable to have the entire space on the inside of the cylinder filled with oil, as there would be no room for expansion of the oil. The work done in checking or controlling recoil generates heat, and it would be impossible to hold this oil by any packed joint or stuffing-box, when the oil, an incompressible medium, expands, unless an air space were provided.

We are likewise inclined to question the advisability of the piston rod passing through the casing. The stuffing-box requires regular attention to keep it in proper condition. It also becomes necessary to provide special protection for the rod itself to prevent dust and grit from lapping the rod and gland. It is also necessary to have a tight fit between rod and packing in the stuffing-box to prevent oil wastage and to retain maximum pressures. This produces friction negative to spring compression which has the effect of stiffening the spring for short and sensitive vibrations during spring compression. There is likewise a marked tendency for the oil and air to become thoroughly mixed, producing a spongy resisting medium.

Hydraulic Friction Types

The Houdaille shock absorber, Fig. 11, is a hydraulic device for controlling spring recoils. It introduces no resistance to compression other than the resistance of the paddle journal in the stuffing-box. The recoils of the spring are controlled by the hydraulic resistance of oil passing through by-passes in reciprocating paddles or rotary pistons. The resistance is always in proportion to the speed of spring recoil. An auxiliary oil chamber is provided outside of the casing proper to replenish any oil waste around the journal or stuffing-box. It is highly essential to have the casing proper filled with oil at all times, otherwise there would be a cavity in the casing,

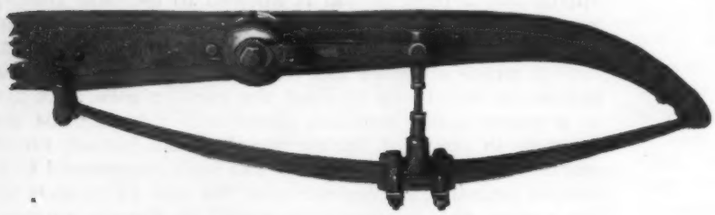


FIG. 11—HOUDAILLE HYDRAULIC FRICTION SHOCK ABSORBER

which would produce a "slap" at the start of recoils. With the slightest loss of oil around the journal, the paddle produces a suction on the oil reservoir, replenishing the leakage.

The chief objection to this construction is that no space is allowed in the casing for expansion of the oil. The heat generated in the oil by the work of controlling the spring recoils will cause the oil to expand, forcing it out around the stuffing-box. There is also the objectionable feature of the inertia of the resisting oil to be considered. The sudden change of direction of the flow of oil in violent and rapid spring actions makes it impossible for the oil to follow after the pistons or paddles without a very violent agitation or frothing. This agitation produces more resistance to compression than it should and likewise has a tendency to saturate the oil with fine bubbles of air. The mixing of air with oil tends to make the resisting medium spongy instead of incompressible.

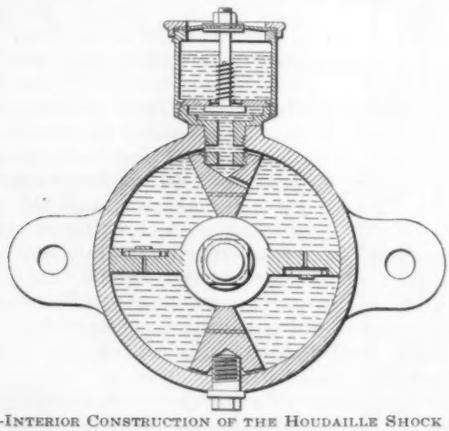


FIG. 12—INTERIOR CONSTRUCTION OF THE HOUDAILLE SHOCK ABSORBER

The author will now refer to his personal experience in the design and development of a device for controlling spring recoils.

About seven years ago we attempted to design a shock absorber to control spring recoils. One design succeeded another with many changes and modifications. However, we confined our efforts exclusively toward the development of a hydraulic recoil check.

Evolution of the Hydraulic Recoil Check

The first commercial Landis model is shown in Fig. 13, a sectional view representing the action during spring recoil. The rotating arms which are attached to lever

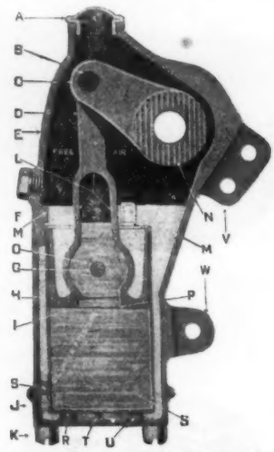


FIG. 13—FIRST COMMERCIAL LANDIS MODEL DURING SPRING RECOIL

N and the support arms attached at W and V are omitted from this view.

Fig. 13 shows the absorber at the start of spring expansion; the oil below the piston I in steel cylinder H is put under pressure when the spring expansion starts, forcing the oil through the orifice T, which is constant in

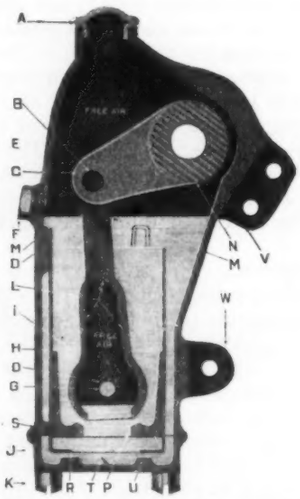


FIG. 14—SAME MODEL AS FIG. 13 AT START OF SPRING COMPRESSION

size. By means of the air in chamber L in piston rod D a pneumatic cushion is provided for changing the direction of action of the spring. The air is compressed to the point of resistance of the orifice T, after which compression the resistance is in proportion to the speed of the spring recoil.

Fig. 14 shows the condition at the start of spring compression; the link C carries the piston rod upward, first opening the ball valve P and next carrying the piston I up through the steel cylinder H. This action produces a partial vacuum under the piston I, which

causes the steel cylinder *H* to move upward to the point determined by the guide lugs *M*. This movement permits of free openings to the interior of cylinder *H*, through the bottom of the cylinder at *R* and through the piston at *P*, enabling the cylinder to fill instantly with oil. It will be readily seen that this action does not interfere with the resiliency of the spring or in any way retard spring compression.

When spring compression is complete, and spring expansion starts, the piston rod *D* first seats on the seat in piston *I*, closing the valve at *P*, then the steel cylinder seats itself on the seat *V*, closing the space between the bottom of the cylinder and piston, with exception of orifice *T*, through which the oil is forced by the downward movement of piston *I*.

Although our original experimental designs were purely hydraulic types, this model is in reality a hydraulic-pneumatic type of shock absorber. We found that we were not always able to fill the cylinder *H* with oil, and to provide for the "pound" or "slap" which gave an acceleration at the start of recoil, we provided the air cushion in the connecting rod.

We were still troubled with oil leakage around the journals of the rotating arms which clamp on the link *C*. We used relief valves to equalize the air pressure on the inside of the casing when the compressed air in the piston expanded after spring recoils. We attempted to pack the joint at journal *N* without increasing frictional resistance to spring compression, but without success. We attributed leakage of oil to the sudden expansion of air in the hollow piston rod, but finally we decided that it would be better to change the direction of flow of the oil after it was discharged from the bottom of the cylinder through the orifice *T*. Instead of discharging the oil all around the

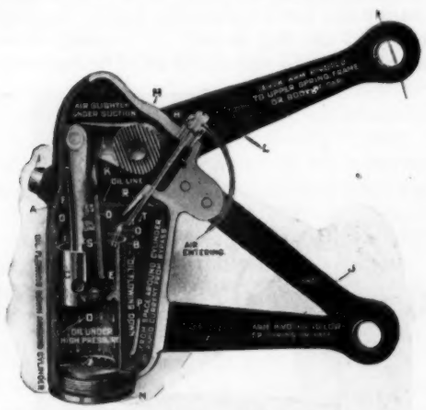


FIG. 15—MODEL SIMILAR TO FIG. 13, BUT WITH CHANGED CASING CONSTRUCTION—SPRING RECOIL POSITION

A—Casing.
B—Floating cylinder.
C—Piston.
D—Hollow connecting rod.
E—Ball valve.
F—Air pipe.
G—Bypass plate.
H—Ring air valve.
I—Oil filling plug.
J—Stationary arms.
K—Short lever
L—Rotating arms.
O—Guide lugs for cylinder.
P—Baffle plate.
R—Oil deflector.
S—Air chamber.

steel cylinder we modified the construction of the casing as shown in the sectional view, Fig. 15.

This construction used a by-pass plate *G* which discharged into an offset portion of the casing. During spring recoil this action discharges the oil over by-pass plate *G* causing the discharged oil to establish a current back of the baffle plate *P* along the outside of the casing, the current being deflected by oil deflector *R* discharging downward around the outside of cylinder *B*. When cylinder *B* is raised from its seat at the start of the compression movement, the oil is moving in the proper direction to enter the cylinder at valve *E* and over by-pass plate *G* into the bottom of the cylinder. The cylinder can be filled instantly as the oil current is always travelling in the same direction, regardless of whether the spring is compressing or expanding. See Fig. 16.

With the air chamber in piston rod we found small bubbles of air would mix with the oil above the oil line. By means of the valve mechanism at *H* we were able to separate the air and oil, allowing the air to escape during

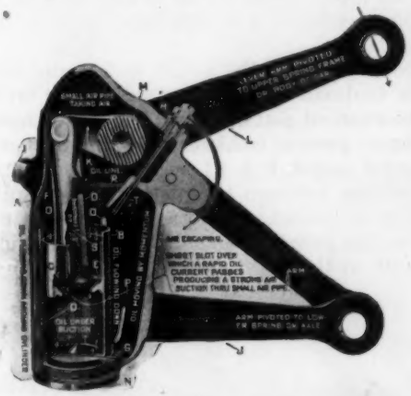


FIG. 16—SAME MODEL AS FIG. 15—SPRING COMPRESSION POSITION

spring compression; the separated oil returned to the casing proper through the small pipe *T*, the current of oil passing the end of this pipe producing a suction to return the oil.

On the recoil movement of the piston the air in the hollow piston rod is compressed. The wafer valve *H* cuts off outside air communication, and the air above the oil line becomes slightly rarefied owing to the compression of air in the hollow piston rod. This produces a suction inward. As the valve *H* is closed, the only place for air to enter is around the journals at *M*. The expansion and contraction of the air in the hollow piston rod in connection with the air valve made it possible to eliminate the breathing action which tended to cause oil leakage at the journals.

Air was replenished to the air chamber by the rush of oil over the slot at the terminal of the small oil pipe *F*, on the face of the piston rod.

This model did not waste oil and handled spring recoils very satisfactorily. However, we were not satisfied with its design and again modified the construction as shown in Fig. 17.

Latest Landis Model

In this design we dispensed with the air chamber, reduced the lift of ball valve in piston and increased the lift of cylinder *B*. By the elimination of the air chamber we have done away with the breathing action on the inside of the casing, greatly simplifying the construction. We have also been able to introduce a hydraulic resistance immediately at the start of spring recoils. This is made possible by the fact that we do not have the oil inertia to take care of due to sudden changes of direction of oil travel.

We question whether any hydraulic device for checking recoils will be successful unless the oil flow is always in the same direction, for the speed with which violent spring action occurs makes it imperative to eliminate the inertia effects of sudden changes of direction of the oil travel.

The latest design, described above, seems to fulfill the

requirements of the shock absorber which we started to produce seven years ago.

The device to the left of Fig. 20 was our first model. It was a failure due to excessive oil heating, mixing of air and oil, stuffing box maintenance, lapping of piston-rod due to grit and dirt accumulation, oil inertia effects and innumerable other defects. The model shown on the right of this view was our next distinct model. The floating cylinder was first used in this model. The same general faults existed in this model.

The third type, shown in the center of Fig. 20, had as its only improvement a slight improvement in external appearance.

The model shown on the left, Fig. 21, was the first employing an enclosed casing, eliminating the troubles incident to the exposed piston rod. This model, however, had the other same general weaknesses as the former models.

The central model, Fig. 21, was the first to use the ball joint connection between the piston rod and piston, with air chamber in piston rod. Leaky joints at upper arm journal was the greatest difficulty with this model.

The model on the right, Fig. 21, had a casing so made

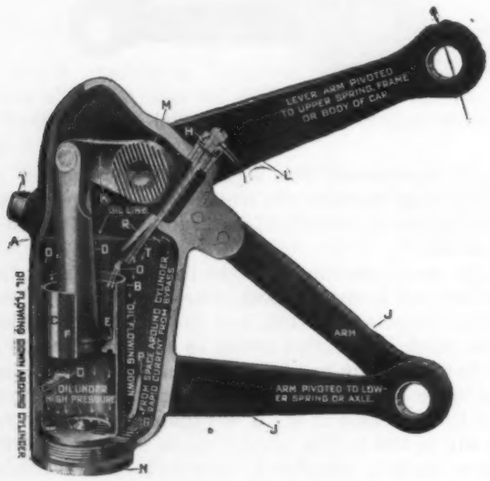

LEVER ARM PIVOTED TO UPPER SPRING FRAME OR BODY OF CAR.
ARM
ARM PIVOTED TO LOWER SPRING OR AXLE.
OIL UNDER HIGH PRESSURE
OIL FLOWING DOWN AROUND CYLINDER

FIG. 17—LATEST MODEL LANDIS SHOCK DIFFUSER WITHOUT AIR CHAMBER—SPRING RECOIL POSITION

A—Casing.
B—Floating cylinder.
C—Piston.
D—Connecting rod.
E—Ball valve.
F—Wrist pin.
G—Bypass plate.
H—Ring air valve.
I—Oil filling plug.
J—Stationary arms.
K—Short lever.
L—Rotating arms.
O—Guide lugs for cylinder.
P—Baffle plate.
R—Oil deflector.

as to deflect oil from the outside wall to center of casing where the shape changed from a round to a flat section. Its greatest difficulty was oil leakage and inertia effects owing to change of direction of oil travel. This is an exterior view of our first model offered for sale.

TESTING SHOCK ABSORBERS

Any test mechanism that does not provide for the violent oscillation of the unsprung weight and which does not show the return of the chassis to its normal static load position, as well as the time required to return, is worthless and misleading. The author suggests a test mechanism as in Fig. 22 for showing actual conditions.

By arranging the spring suspension to travel over an endless-belt highway at a predetermined speed, with a reducing motion connection between the recording chart and highway, we could accurately and graphically record the true conditions existing in any spring suspension. We believe it would be for the best interests of all concerned to spend a little time and effort obtaining some honest technical data on this subject. If future tests do not verify expectations, we should try to find out wherein the difficulty lies.

The shock absorber manufacturers of this country

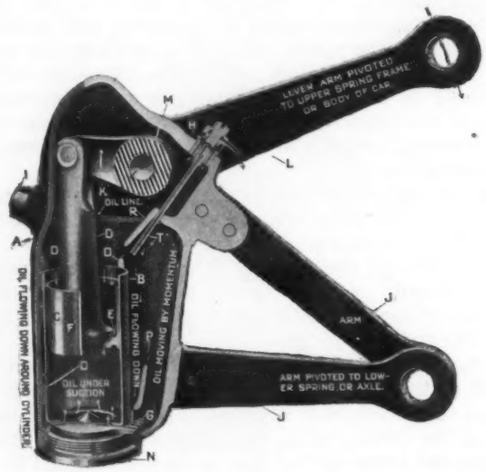

LEVER ARM PIVOTED TO UPPER SPRING FRAME OR BODY OF CAR.
ARM
ARM PIVOTED TO LOWER SPRING OR AXLE.
OIL UNDER SUCTION
OIL FLOWING DOWN
OIL MOVING BY MOMENTUM

FIG. 18—SAME MODEL AS FIG. 17—SPRING COMPRESSION POSITION

have been laboring under a great handicap, due to the fact that there seems to be great reluctance on the part of automobile manufacturers to consider the use of any auxiliary equipment. The accessory manufacturer must create the demand; he must force the automobile manufacturer to change his car because the public demands it. We fully believe that the day is not far distant when we will see marked changes in the designs of automobile spring

FIG. 19—EXTERIOR OF LATEST MODEL LANDIS SHOCK DIFFUSER

suspensions, which will have ideal springs in connection with ideal shock absorbers.

AMBULANCES

The need of shock absorbers, in fact the need of entirely new spring suspensions for ambulances, is self-evident. We saw a U. S. Army ambulance in Washington a short time ago that was being tested with a view of securing better and easier riding qualities. The chassis of this ambulance was that of a three-quarter ton truck; the springs were so heavy that a sand ballast of about

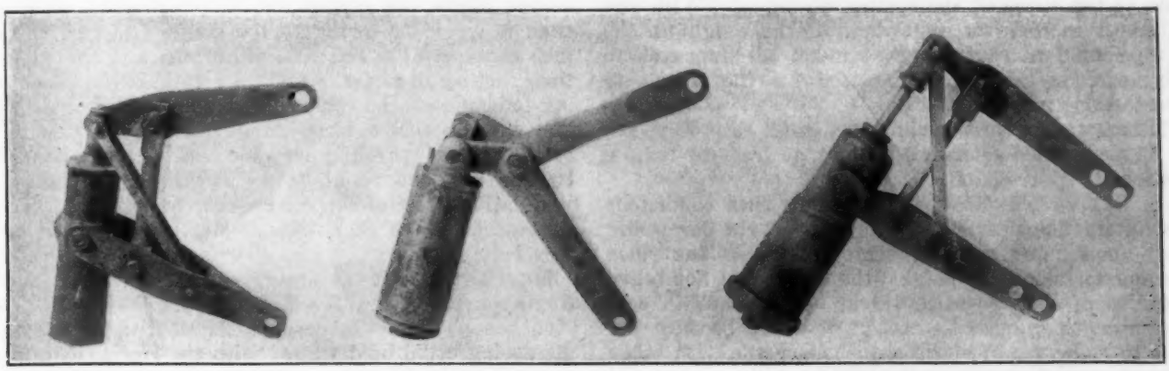


FIG. 20—EXTERIOR VIEWS OF LANDIS EXPERIMENTAL MODELS. FIRST AT LEFT; SECOND AT RIGHT; THIRD IN CENTER

FIG. 21—EXTERIOR VIEWS OF LATER LANDIS EXPERIMENTAL MODELS. FIRST WITH ENCLOSED CASING AT LEFT; NEXT MODEL OF SIMILAR TYPE IN CENTER; FIRST COMMERCIAL MODEL AT RIGHT

1000 lb. was necessary in order to make the car fit to carry a well man. Pity the poor wounded men who have to ride in such ambulances!

AUTHOR'S CONCLUSIONS

Spring suspension designs should provide sufficient range of movement to take care of all loads from maximum to minimum, using a spring of low rate. To secure easy riding it is folly to attempt to use a spring that has a very small range of movement with a high rate. Shock absorbers should not be expected to improve such conditions. Some life should be put into the spring, and its recoils controlled by a suitable shock absorber.

Summing up the requisites of an ideal shock absorber, its design must be in accordance with the following conditions:

1.—No neutral points in its action.
2.—High road speeds with comfort and safety.
3.—Control of spring recoil.
4.—Recoil soft and gentle.
5.—Springs must not be stiffened.
6.—Friction must be a function of recoil, not a constant.
7.—Introduction of a recoil time element in proportion to the speed of spring expansion.

We can best illustrate the fact that resistance to recoil should be a function of the speed of spring recoil by a simple procedure. The upper arm of such an absorber as shown in Fig. 19 can be lifted by a cotton thread, if sufficient time is taken to raise the arm. In other words, with a slow spring expansion or slight spring movement the resistance to recoil is slight. On the other hand we can tear a heavy hemp rope if we attempt to lift the same upper arm in a short time, that is, with a fast spring expansion or excessive recoil movement we introduce a strong resistance to recoil.

THE DISCUSSION

CHAIRMAN JOHN W. WATSON (M. S. A. E.):—I have noticed that automobile designers seem to regard a recoil check on a spring as something that will tend to lift the axle from the ground.

MR. LANDIS:—The opposite is true. The spring is held under light tension during its recoil, and there is no tendency for the wheel to leave the road surface. The instant the spring expands beyond its normal position perfect adhesion between tire and road ceases and the tire tends to be lifted from the road. The axle certainly will not be lifted from the road before the spring reaches its normal position. This position is determined by the spring deflection, which is dependent upon the weight of the body and the load in the car.

If we were to put a jack under the body of the car, we would have to lift the car beyond the normal position before the wheels would be off the ground. Up to that point we would be lifting only the body and its load, but the instant the normal point had been passed the weight would be taken from the wheels. We would still have the dead weight of the axle and wheels pulling down or tending to open the spring.

CHAIRMAN WATSON:—The wheel would not be lifted from the ground until the spring had passed considerably beyond the normal position?

MR. LANDIS:—Yes, the load would be off the tire but the weight of the wheels would still be on the ground. Before the wheels are actually lifted from the road, the car must be well above the static load position. It seems to me that the recoil check also keeps the spring under compression during the recoil.

If the wheels pass over a depression, they will naturally tend to follow the road surface. The resistance to opening of the spring offered by the recoil check is propor-

tionate to the speed of the spring movement. With any recoil check mechanism, regardless of the weight in the car, we should not introduce so much resistance as to greatly prolong the period required for the wheels to return to their normal position.

A MEMBER:—When traveling at a high rate of speed, what happens when a series of bumps, such as car tracks, are struck?

R. S. CARTER (M. S. A. E.):—Under such conditions the resultant displacement of the body of the car would depend upon many variable factors such as the ratio of sprung to unsprung weight, the speed, the flexibility and period of both front and rear springs. With certain combinations of these factors it would be most desirable to make use of shock absorbers, while with other combinations undesirable, unless the flexibility and period of the car springs and the action of the shock absorbers were such as to properly co-act.

A MEMBER:—How should the ideal spring suspension, as mentioned in Mr. Landis' paper, be designed?

MR. LANDIS:—That depends upon the type of spring used under the vehicle, and also upon the speed of the car. If the unsprung weight could be kept down to a

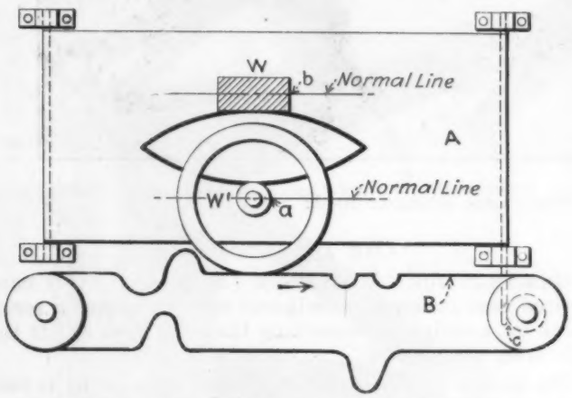


FIG. 22—SUGGESTED AUTOMOBILE SPRING TESTING APPARATUS
Sprung weight, *W*. Unsprung weight, *W'*. Pencil points, *a* and *b*. Record sheet, *A*. Traveling highway, *B*. Worm drive between highway and record sheet, *c*

minimum, the spring rate could be greatly reduced. I consider that the spring rate should be determined by the weight of the axles, wheels, body, the live load in the car, and the range of spring movement necessary to meet average road conditions. On meeting an obstruction the unsprung weight imparts a certain compressing force to the spring. If the range of spring movement were not sufficiently large, it would be necessary to increase the spring rate.

MR. CARTER:—The springs should be made very flexible?

Preventing Cumulative Shock Effect

MR. LANDIS:—Yes, for the blows delivered to the springs would then be much less owing to the fact that with the recoil controlled they would not have a cumulative effect. Several tests I have made show that ideal riding conditions can be secured on rough roads if the spring recoil is controlled.

If a spring with a range of movement of six inches, and not provided with recoil control, is compressed two inches when the wheel strikes a certain obstruction, recoil or free vibration of the spring will follow immediately. Now, if the spring strikes a second bump two inches high and if the free vibration is in phase with the blow at the second bump, the spring will be compressed much more than it would be owing to the single effect of the two-inch obstruction. The free vibrations and forced vibrations, acting in phase, result in a cumulative effect tending to compress the spring. For this reason, a very flexible spring with a large range of movement will "hit bottom" when traveling over comparatively smooth roads. If, however, the recoil of the spring is controlled, the cumulative effect of the road shocks is destroyed, making it possible to use an extremely flexible spring to secure easy riding.

MR. CARTER:—If the springs on a car were to serve a single purpose, and for but one kind of road, shock absorbers would not be needed. If all roads were smooth, the spring could be designed with the right flexibility so that no shock absorber would be needed; that, of course, is impracticable. Low and high speeds, light and heavy weights and varying road surfaces are conditions requiring different types of springs. For years I have been working to perfect a shock absorber to co-act with a spring of high flexibility in such a manner as to obtain a flexible spring action for good road conditions but with an increasingly stiffer spring action as the load and speed increase and as the road surface becomes rougher.

CHAIRMAN WATSON:—Should not the resistance to recoil start from a zero value?

MR. CARTER:—It starts from zero and builds up. At the first impact of the blow, it should start to absorb the energy imparted by the shock. If it does not start with the shock impact the springs will collapse farther and a much greater resistance will have to be applied in order to check the car springs on the rebound. This greater resistance of the shock absorber against recoil will materially affect the recovery of the car springs under certain road conditions where a quick recovery is essential to comfort.

MR. LANDIS:—With a hydraulic type, on the other hand, the resistance decreases with the car speed. That is the trouble I see with most friction recoil devices.

I have seen this tried with very soft flexible springs on cars running at 20 m.p.h.; when passing over ordinary obstructions each spring becomes completely straightened. We tested a car fitted with a suspension designed in accordance with our suggestions, and the springs seemed to be too weak. We controlled the recoil without interference with the compression, and the springs then failed to "hit bottom," even at high speeds.

MR. CARTER:—Most discomfort comes from heavy forced vibration, occasioned when running into holes or ruts; unless shock absorbers are used automobile manufacturers are obliged to supply springs that will meet the worst road conditions even at the sacrifice of comfort. Springs that are not supported during compression by some form of shock absorber are essentially heavier springs which have not as good riding qualities under good road conditions as more flexible springs.

Instead of controlling the recoil alone after the spring has moved considerably under compression, will it not be better to start to absorb the shock energy at the time of impact, in view of the fact that a definite number of foot-pounds of energy must be absorbed and the earlier the absorber comes into action the longer the time it will have to absorb this energy?

MR. LANDIS:—Mr. Carter is attempting to absorb the energy with a short movement by using a spring of a variable rate. It is quite true that some of the impact will thus be absorbed, but the tendency to pitch the car from its straight-line travel will be increased while the

spring is being compressed, because the spring is of a higher rate. The impressed force acting upon the body is greater, hence the pitching of the car will be greater during compression of the spring.

All that is necessary is to provide a slight resistance so that when the spring is coming back there will be no slap or pound, as there is with a free spring. If the recoil can be controlled immediately at the start, the recoil movement can be overcome with slight resistance much more satisfactorily than if it is allowed to accelerate before attempting to stop it.

MR. CARTER:—Mr. Landis brings out just the point I was approaching, which is that very flexible springs can be used with safety on a car provided they are supplemented and protected against the forced vibrations of impact shocks by the co-action of a properly designed shock absorber.

The combined resistance of the flexible spring and absorber, if equivalent to the resistance of the heavier unsupported spring, will offer an equal resistance against shock, but at the same time will have the advantage that the recoil of the more flexible spring will be much less, requiring a less damping effect on the part of the shock absorber in the recoil direction which is most desirable over certain road conditions.

An advantage of using springs of high flexibility is that (as their variation, per inch of motion, is less than that of stiff springs) their supporting action against the frame of the car is more nearly constant when the wheels of the car are passing over the uneven surfaces of the road. For example, comparing the action of a spring of 600 lb. per inch and one of 200 lb. per inch in passing over a mound 2 in. high, the former increases its pressure against the frame by 1200 lb. and the latter by only 400 lb., and conversely when passing through a depression of 2 in. in the road the heavier spring reduces its support against the frame by 1200 lb. and the flexible spring by only 400 lb. With the flexible spring the variation of support against the sprung mass of the car is only one-third that of the heavier spring.

As the ideal suspension must allow motion of the unsprung parts without variation of reaction of the supporting elements against the sprung mass it is evident that the more nearly this variation is brought to zero the nearer do we approach the desired but unobtainable straight line travel of the sprung mass.

Spring Rate Should Be Low

MR. LANDIS:—In order to provide easy riding, I believe that the rate of a spring should be as low as possible. If a combination of a stiff and flexible spring, or a spring with a variable rate (increasing from a low to a high rate) is used, the resultant force due to the high rate naturally tends to disturb the straight line of travel of the car body. If the rate of a spring is a constant, then the resultant force will not greatly disturb the inertia of the car body, provided the range of spring movement is sufficiently great.

MR. CARTER:—I agree with Mr. Landis that for good riding it is essential to work toward the use of suspensions of higher flexibilities than are commonly used today; also that to make such suspensions practicable and commercial it will be necessary that some form of auxiliary attachment be used to reinforce their action to meet the varying road, load and speed conditions.

ERNST FLENTJE:—About seven years ago, at the New York Automobile Show, I stated that three essentials are necessary to make a car ride flexibly, sensitively and safely: first, sensitive cushions; second, long, flexible springs; third, automatic shock absorbers. The main spring of an automobile cannot act quickly enough when going over little holes in the road. In such cases a sensitive cushion will take up oscillation or quiver that the main spring, when carrying a light load, cannot follow quickly enough.

I have found by experience that the half-elliptic spring gives better satisfaction and more sensitive riding qualities with a light load than the three-quarters or full elliptic spring. When only two or three people are riding in a seven-passenger car (having springs designed for a seven-passenger load) the springs will not oscillate freely and the car's motion will be choppy.

Importance of Spring Finish

The average automobile springs are not properly finished; the scale from the rolling mill is left on, and in many cases the spring is not shaped properly. A spring not properly scraped acts like a file; such a spring, if taken apart after 4000 to 5000 miles of use, would show many imperfections causing friction and preventing free oscillation.

To overcome lack of sensitiveness in springs, I go over the spring leaves with an emery wheel, taking off the roughness and scale, then I put them on a felt wheel and polish and apply oil and graphite. Then I place a strip of specially prepared spring phosphor bronze between every leaf. This treatment increases the flexibility from 20 to 25 per cent. By this means a seven-passenger car can be made comfortable and very sensitive when two or three persons are riding, but if the car is also equipped with automatic shock absorbers it will be equipped for shocks of either one or one thousand pounds, the latter actually occurring at high speed when meeting road obstructions.

The point has been mentioned that the shock absorber must take solid hold immediately on the recoil. I employed that principle for nearly five years, but found that it was wrong. When we equip a car the device is attached in the front between the axle and frame, so as to allow from 3 to 3½ in. of movement between the bumps. The rear attachment depends entirely upon the action and the length of the springs, but a piston travel of from 4½ to 6 in. is usually provided.

E. R. WATERMAN (A. S. A. E.):—It is our belief that there will always be several types of shock absorbers and that no one type will be the ideal. The Hartford shock absorber will exert a force of about 1000 lb. on the upward stroke, but not over 35 lb. on the downward stroke. The shock of the blow has a tendency to release the absorber spring momentarily, as it were, and when the spring is compressed completely the amount of tension is the greatest, so that the spring is not allowed to jump across the gap. With the gradual starting from zero, it has full control of the spring and the recoil cannot be violent.

CHAIRMAN WATSON:—A spring requiring 200 lb. to compress it one inch will require 400 lb. to compress it 2 in. If only 35 lb. is used on the downward stroke, how can that have any effect:

MR. WATERMAN:—The Hartford shock absorber takes care of violent recoils. It depends upon the pneumatic tire to absorb the small vibrations when there is no such recoil. We tried the neutral shock absorber having multiple disks, but actual use proved that it did not work out satisfactorily. We do not believe that spring manufacturers can ever overcome the handicap of the varia-

tion of load caused by changing the number of passengers and by operation under all kinds of speed conditions. Car manufacturers equip seven-passenger cars with springs for carrying their weight. Over half of the time there will not be more than two or three people in the car. A lightly loaded car will have more vibration. Shock absorbers are needed more when a car is only partly loaded than when the load is normal. We believe all makes of shock absorbers are good, but there is a field for each.

MR. LIEBAU:—The Westinghouse air spring has a telescopic cylindrical air chamber, giving the full movement of the steel spring and a six-inch movement of the air spring. The air springs are inflated to a pressure sufficient to carry the car with a given body load. The air pressure is governed by the weight of the car; for the light car it is from 35 to 40 lb. per sq. in. and for heavier cars from 45 to 90 lb. We do not govern the absorber by the pressure in the spring, but by the position after it has been inflated.

The oil used has three functions: to seal the air, to lubricate the moving parts, and to operate the little single-acting oil pump for pumping the oil back into the spring to level the oil.

Our experience shows that it is necessary to have very flexible springs with long range at both ends of the car. Engineers with whom I have come in contact do not seem to consider that blows on the front end of a car have as much to do with the action as those on the rear. A car equipped with these devices on the rear only will not give as comfortable riding as one equipped both on front and rear.

We find that in order to get satisfactory results with our equipment the steel spring under the car must be sufficiently heavy to support the load under normal conditions, and of sufficient strength to work safely on average roads without striking the axle.

Air Shock Absorbers Give Long Range and Flexibility

The air shock absorber results in a long range of flexible spring action, thus allowing the wheel to follow the inequalities of the road without following the straight-line travel of the body; that is the real reason why an air spring was conceived. I do not believe any device has been conceived as yet that will absolutely eliminate all road shocks or rebounds, but we are all working to that end.

(*Written Discussion*)

JOHN W. BLACKLEDGE (A. S. A. E.):—The question of easy riding is so important that for the past fifteen years automobile companies have spent millions of dollars in changing their springs from one type to another. This has necessitated changing the framework and general construction of cars. They have used half, three-quarter and full elliptic springs, platform, cantilever, and have come back again to half elliptic springs. They have had short, long, wide and narrow springs, thick leaves and thin leaves, with many different methods of support. All of this has been for the purpose of obtaining easier riding and to avoid wear and tear on the car. The matter of springs must, therefore, be considered of great importance to automobile interests.

Spring Shock Absorbers Take Care of Small Bumps

The springs of an automobile must be made strong enough to support the heaviest load and keep the car from striking the axle. A spring cannot be made which will have the correct strength for both a 1500-lb. and a 50-lb. load. Spring type shock absorbers take care of variations of load and adapt themselves to any load. Their coils, being softer and more resilient than the main springs, work faster than the main spring and absorb the thousands of small vibrations before they are carried to the body of the car. Manufacturers of the type of shock absorber known as the recoil check state that the spring type does not resist the upthrow of a car. In this they are mistaken.

The two following illustrations will serve to explain the manner in which the spring type helps to absorb the big shocks.

A solid steel ball one inch in diameter was observed to bounce twice to the height of about three feet on a hard floor and on the third bounce it fell on a rubber matting. When it struck the rubber matting it bounced about one inch and stopped dead. The resilience of the rubber matting absorbed the shock and killed the upthrow, the same as the "give" in the coils of the spring shock absorber kills the greatest part of the rebound of a car. If a man jumps from a table to the floor, alighting on his heels stiff-legged, it will give him a painful jar, but if he alights on his toes with knees bent, there is no discomfort whatever. The bend in his knees and the spring of the toes kills the shock and answers the same purpose as a spring shock absorber.

Many people do not understand the principle illustrated above and therefore claim that a car must have a recoil check or strap to stop the upthrow. Such recoil checks do help cars having main springs which are too resilient or are not properly made and correctly set.

Recoil Shock Absorbers Required for Large Bumps

The large bumps, for which the recoil check type is required, do not occur oftener, on an average, than once in 800 feet, while in the space of 800 feet there are hundreds of small, jerky vibrations caused by cobble stones and railroad tracks eliminated by the cushion type of shock absorber. The cushion type, therefore, does more good than the recoil check type.

Each type, however, has its own particular use, depending upon the individual car to which it is applied. Several types of cars have springs which cannot be fitted with spring or cushion type shock absorbers, and such cars the recoil check will greatly help.

Shock absorbers cause a great saving in the wear on tires and on the general wear and tear of the entire car. The general manager of the truck department of one of the largest automobile companies in America, after using shock absorbers on a six-months test of his truck, stated that he was satisfied that they would result in lengthening the life of the truck 25 to 35 per cent.

FRANK R. FARNHAM:—The development in passenger automobile spring suspensions has been due to two reasons: First, because sales have depended to a great extent upon the comfort of the passengers as well as upon the power, speed and flexibility of operation of the chassis. Second, it has been recognized by manufacturers of automobiles that the very vibration which it is desired to eliminate in order to secure the comfort of the passengers is also the cause of many minor repairs and adjustments to the engine, transmission, and chassis in general.

Passenger automobile spring suspensions have been developed to a very high degree with a marked tendency toward the use of long and fairly flexible springs having a comparatively slow period of vibration. Yet even with

spring suspensions of this character a large number of automobile owners have found it advisable to use shock-absorbing devices of one sort or another, in order to check the rebound of the springs when traveling over rough roads or pavements.

Since the total weights carried by most passenger automobiles are comparatively light, and since, in the interests of the passengers' comfort, their spring suspensions have been developed to a very high degree, the effect of such spring stiffness under light loads is not intolerable.

Very different conditions, however, prevail in the case of the commercial vehicle.

Here the vehicle carries heavy loads; it is or should be a direct producer of revenue and the extent to which it earns revenue depends strictly upon the continuity with which it is kept at work hauling the paying loads.

Moreover, the percentage of difference in weight carried on the spring suspension, between the empty and fully loaded conditions, is much greater than in the case of the passenger vehicle.

That the presence of a load on the chassis of a motor truck does have a very marked effect upon the spring action cannot be denied by any one who has ridden any distance upon a commercial vehicle when it was empty and then traversed the same route when the truck was carrying its full capacity load.

In designing motor truck springs the engineer has been forced by conditions to provide a suspension with an ample factor of safety, not only to carry the rated load, but also to cope with the excessive overloads which may be carried on it in emergency.

Such a factor of safety naturally presupposes a strong, rugged spring—one having ample strength to carry the truck chassis and the pay-load and which under such load will show a fair degree of resiliency. This spring, however, will be deflected very little if any when the vehicle is operating empty or in the lightly loaded condition.

No one spring can be designed for motor truck service that will develop equal resiliency under both light and heavy loads, and this fact would indicate the advisability of using auxiliary springs which shall automatically come into action when the load on the truck is reduced to such a point that the main springs show insufficient resiliency. These auxiliary springs should also automatically go out of action and transfer their work to the main springs of the truck when the load carried thereon is sufficient to develop the resiliency for which the main springs are designed.

Such a dual type of spring suspension would effect a very material reduction in the vibration reaching the chassis when the vehicle is traveling lightly loaded or empty, and any vibrations reaching the chassis would be very much reduced in sharpness.

Vibration Causes Kidney Trouble

Practically all of the kidney trouble, so prevalent among truck drivers, is due to the vibration to which they are subjected during their daily work—vibration which is at its worst under just the conditions when the driver should be pushing his truck along the fastest, that is, when returning empty for another pay-load. The truck owner's labor turnover among his drivers will be materially reduced by use of the dual type of spring suspension.

There is already on the market a device which actually does constitute dual spring suspension in connection with the regular leaf springs of a motor truck, such as above referred to. With such slight modifications as the design of a given truck may require, the Kim auxiliary spring consists of a pair of heavy coil springs of the torsion type. These are mounted in the yoke in such a way that their inner ends are attached to a riding member of the yoke, while the outer ends are fastened to a stationary member.

So long as only a light load is carried, or the truck is driven empty, this auxiliary arrangement performs practically all the spring action. When the truck is loaded up to or beyond its rated capacity, the torsion springs embodied in the Kim spring assume a locked position, in which they are subject to no further stress or action, and the entire load of the truck is carried on the regular leaf springs, which of course are then operating under conditions of maximum resiliency.

The entire assembly of the Kim auxiliary spring is so arranged that if through accident either or both of the torsion springs should be fractured the assembly would hold together, then performing the same service as the regular spring shackle which it replaces.

One large express company has installed a set of Kim auxiliary springs, purely on trial, on an Autocar truck operating over a route which is paved with extremely rough granite block. A close check was kept on all expenditures made for this particular truck, and at the end of the sixty-day test period it was found that the total outlay on the truck, with the exception of that made for gasoline, oil and tires, was only seventy-five cents, as against a previous maintenance cost of ten dollars or more a month.

(*Discussion contributed after adjournment.*)

R. S. CARTER (M. S. A. E.):—It is, I believe, acknowledged by automobile engineers that a spring suspension of a given flexibility produces comfortable riding over only a narrow range of road, load and speed conditions. Further, it is generally acknowledged that to produce the greatest comfort when riding over cobbles and rippled roads at low speeds very flexible springs should be used, and conversely for fast driving over heavy and rough roads stiffer springs are imperative, not only to secure moderate comfort, but also to adequately protect the car from damage.

Some automobile manufacturers attempt to meet these conditions by supplying springs of different flexibilities. One European manufacturer even goes so far as to have available springs of over thirty different flexibilities; the weight of the body, average number of passengers, conditions of roads encountered and the usual speed at which the car is to be driven are considered when the springs are selected for each car. Good results can thus be accomplished, as the roads are universally good in Europe, and those driving the cars have learned to go carefully over the few stretches of bad roads which may be encountered.

In this country, where road conditions vary so greatly, automobile manufacturers have been obliged to make compromises. Some use stiff springs to protect the car over the worst road conditions. Others use flexible springs requiring careful driving, but the majority use stiff springs on front and reasonably flexible springs on the rear.

Shock Absorbers Modify Spring Flexibility

Let us consider how present spring suspension design affects the shock absorber question. The successful shock absorbers on the market may be divided into two classes:

1.—Those acting as auxiliary springs, such as the Westinghouse, U. S. E., etc., which are attached between the end of the car springs and the frame. Their prime object is to add flexibility to the car springs.

2.—Those which are mounted between the axles and frame and reduce the flexibility of the car springs in either one or both directions.

It is evident that where one type is successful the other type would be a failure.

I believe this is the reason for so much controversy as to the success of shock absorbers. Insufficient study having been made in their application, the car springs have not been designed to properly cooperate with them to give the best results.

It is easily understood that with the almost universal method of equipping American cars with stiff front springs and flexible rear springs, the Class 1 type of shock absorber should be used in front and Class 2 on the rear in order to obtain good results.

I have been attempting to make it practicable to equip cars on both front and read with soft springs of high flexibility, allowing them practically free action under slight shocks such as on cobbles, rippled roads, and in city driving, while controlling their action by the use of an attachment called an oil spring which gives an increasingly greater resistance as the road condition becomes less favorable or as the load or speed may be increased.

The combined action of the oil springs and such a set of high flexibility springs gives in effect the action of flexible springs for good road conditions, and of increasingly stiffer springs as load and speed increase and the road surface becomes rougher.

It seems to be a mistaken idea that because the front springs are not under the passengers they do not affect riding. Nothing could be more erroneous, as all the disagreeable vibration from too rigid front springs are transmitted through the car. Again, as the period of the stiff front springs is so out of phase with the more flexible rear springs, the result over certain roads is most unsatisfactory.

Suitable Spring Flexibility Important

When equipping cars of standard makes in this country with oil springs I have found that much better riding qualities can be obtained by increasing the flexibility of the front springs which, when operating in conjunction with the oil springs, do not break through and "hot bottom."

From actual experience I have obtained exceptionally good results with springs of the following flexibilities when using oil springs to control their action:

Supported Load Per Spring.	W'gt Required to Deflect Front Spring One Inch.	Free Clearance Front Spring.	W'gt Required to Deflect Rear Spring One Inch.	Free Clearance Rear Spring.
Lb.	Lb.	In.	Lb.	In.
700	235	3½	117	6
800	265	3½	135	6
900	300	3½	155	6
1000	330	3½	170	6
1100	360	3½	185	6

Fig. 24 shows graphically the results obtained through the use of the oil spring combined with the action of a spring of high flexibility compared with the graphic curve of a stiff spring of low flexibility and of twice the strength per inch. *A* indicates graphically the compression and expansion of a 250-lb. spring under 5 in. of compression. *B* indicates the compression and expansion of a 500-lb. spring under 5 in. of compression.

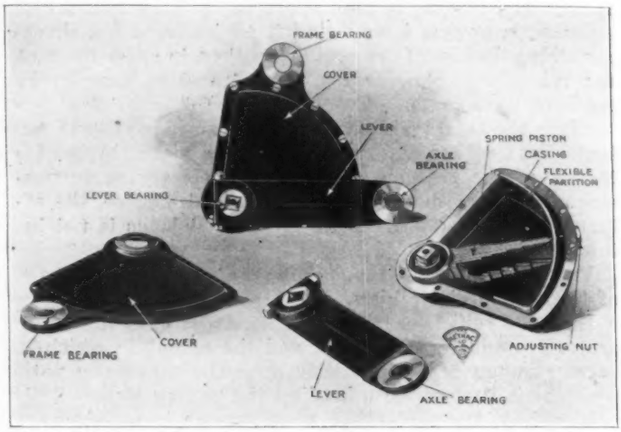


Fig. 23—Interior Construction of the Retrac Oil Spring

C indicates the combined curve of the oil spring and the 250-lb. spring under similar conditions, based on a period of 130 vibrations per minute.

Construction of Laminated Piston Oil Spring

The oil spring, shown in cross section in Fig. 23, is novel in construction in that it employs a flexible laminated steel piston and a flexible collapsing spring steel curved partition operating within the oil chamber in order to obtain a graded resistance which produces but slight reaction against small movements of the axle and increasingly greater resistance the larger the magnitude of this movement becomes. It also produces a greater reaction against recoil at any one point than against impact. Owing to its construction, the resisting parts being made of laminated springs whose flexibility can readily be changed, it offers broad possibilities in obtaining the resistance in either direction that will give the desired

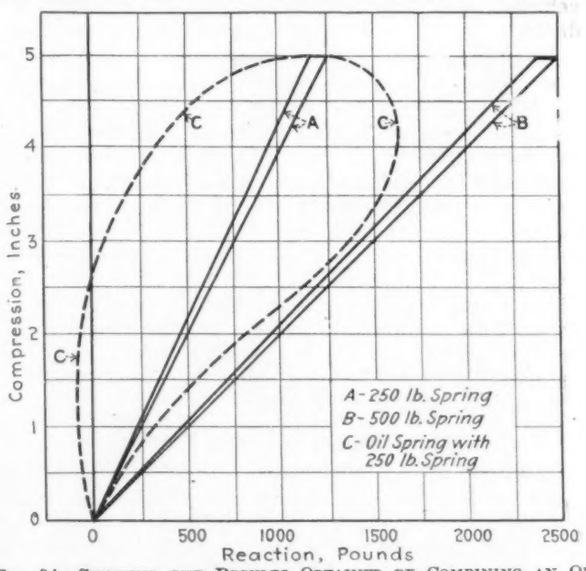


Fig. 24—Showing the Results Obtained by Combining an Oil Spring with a Main Spring of High Flexibility

results without in any way changing the structure of the absorber. The springs acting within the oil, cushion the retarding effect and allow a powerful action to be used without noticeably stiffening the action of the car springs or making the combined action of the car springs and absorber jerky.

Discussion on Steam Automobiles

BENJ. F. TILLSON:—An error appears to have entered the calculations given in Mr. Thayer's discussion of Mr. Doble's paper on Electrically Controlled Steam Automobiles; on the basis of his figures he should claim 92.4 per cent boiler efficiency instead of 90 per cent which was claimed by him for the Doble boiler. His calculations appear to be based on the performance observation figures in Mr. Doble's paper, where the steam pressure is given at 600 lb. per sq. in. gage pressure and the total heat in steam *above a water temperature of* 32 *deg. fahr.* is 1245 B.t.u. per lb. However, the heat in the feed water at 62 deg. fahr. is only 30 B.t.u. per lb. as it must be considered as the heat above 32 deg. fahr. to correspond with the total heat of the steam. Therefore the total heat imparted by the boilers is 1215 (1245 — 30) B.t.u. per lb. of steam instead of 1183 B.t.u., as he calculates it. There are also some arithmetical errors in the equation of efficiency as printed.

With perfect combustion the gases leaving the economizer will carry off about 1.905 per cent of the heat in the fuel for every 100 deg. fahr. that the temperature of the escaping gases exceeds the draft air entering the furnace; for every 10 per cent of excess air required for the furnace draft this loss will be increased about 0.17 per cent for each 100 deg. fahr. temperature rise above entering air. Very probably the excess air will amount to 20 per cent or more, but, on the assumption that it can be limited to 10 per cent, the heat loss will approximate 2.075 per cent per 100 deg. fahr. rise of flue gas temperature above that of the entering air. Mr. Doble's table records the temperature of flue gas as 410 deg. fahr., so that a loss of about 6.85 per cent would be expected from this source if the temperature of inlet air is 80 deg. fahr.

Another serious source of loss of the calorific value of the fuel is that owing to the water vapor formed in the gases of combustion and not reduced to a low enough temperature to condense in the boiler or economizer; the latent heat of vaporization of this water vapor, however, is included in the calorimeter determinations of the heating value of the oil fuel.

The heat lost through this uncondensed moisture will probably approximate 6.26 per cent if the hydrogen in the fuel is 14.4 per cent by weight. So far, losses totaling 13.11 per cent have been noted; to these losses must be added those resulting from radiation of heat and any leakage of gases or any coatings of soot or scale which hinder heat transfer in the boiler or economizer tubes.

It is usually estimated that the radiation of the brickwork setting of boilers amounts to 3 per cent of the heating value of the fuel, therefore an estimate of 1.81 per cent to cover this loss in the Doble furnace and boiler seems conservative. In addition to these losses there is an additional loss due to the humidity of the draft air, and if we assume this to be low (say, 60 per cent humidity) there will be 0.007 lb. of water vapor per pound of air, or 0.1 lb. of water vapor per pound of fuel, and this would amount to an additional loss of 0.08 per cent if flue gases were to leave at 410 deg. fahr. and draft air were admitted at a room temperature of 80 deg. fahr.

Therefore the least total loss expected would be 15 per cent of the heating value of the fuel and a boiler efficiency of 85 per cent would seem very high for it would require a perfect combustion of all the carbon to CO_2 with no CO and no uncombined hydrogen, as every 0.1 per cent by volume of free hydrogen found in an analysis of the resulting flue gases would indicate a heat loss and lessened boiler efficiency of about 0.33⅓ per cent.

Detail Procedure of Analysis

The following computations indicate the procedure of obtaining the figures of this analysis:

Mark's Mechanical Engineers' handbook, page 611, gives 20,093 B.t.u. as the heating value of kerosene (composed of 85.05 per cent, by weight, carbon, and 14.40 per cent hydrogen), which is probably very similar to the fuel used.

Weight of air per lb. of fuel for { Carbon .....0.8505 × 11.52 = 9.45 lb.
{ Hydrogen .....0.1440 × 34.56 = 4.97 lb.

Total weight of air.....14.42 lb.
Weight of fuel..... 1.00 lb.

Total weight of products of combustion.....15.42 lb.

Water formed = $0.1440 \times \frac{9}{11} = 1.2960$ lb.

CO_2 formed = $0.8505 \times \frac{11}{3} = 3.120$ lb.

Nitrogen, by difference .....11.01 lb.

0.1440 (specific heat of water vapor) × 1.296 = 0.622
0.2025 (specific heat of CO_2) × 3.12 = 0.632
0.2438 (specific heat of N_2) × 11.01 = 2.685
3.939

Average specific heat = 3.939 ÷ 15.42 = 0.255.

Heat required for 100 deg. rise of flue gas temperature = 15.42 × 0.255 × 100 = B.t.u....394.

Flue gas temperature = $\frac{394}{20{,}100}$ = 1.96 per cent per 100 deg. fahr.

10 per cent excess air = 1.44 lb.

B.t.u. per 100 deg. fahr. = 1.44 × 0.2374 × 100 = 34.2.

$\frac{394 + 34.2}{20{,}100}$ = 2.13 per cent per 100 deg. fahr. flue gas temperature with 10 per cent excess air.

Water vapor in air (60 per cent humidity) per lb. of fuel = 0.007 × 14.42 = 0.0101 lb.

B.t.u. per 100 deg. flue gas temperature (specific heat 0.48) = 0.48 × 0.0101 × 100 = 4.85.

Loss per 100 deg. fahr. flue gas temperature = $\frac{4.85 \times 100}{20{,}100}$ = 0.0241 per cent.

Total loss per 100 deg. fahr. = 2.13 + 0.0241 = 2.154 per cent.

With 410 deg. fahr. flue gas temperature and 80 deg. room temperature, the rise = 330 deg. fahr.

And the loss = 3.3 × 2.154 = 7.1 per cent.

Loss per lb. of fuel due to uncondensed water in products of combustion 1.296 lb. water of 970 B.t.u. per lb. = $\frac{970 \times 1.296}{20100}$ = 6.26 per cent.

Sensible heat in products combustion	7.10 per cent
Latent heat in products combustion	6.26 per cent
0.1 per cent by volume of uncombined hydrogen	0.03 per cent
Total	13.39 per cent

If 1.81 per cent is lost by radiation, the final boiler efficiency will be about 85 per cent.

Additional Data Desired

In view of the foregoing analysis it seems that Mr. Doble's report on his boiler efficiency is highly optimistic and that the test figures are not as accurate as should be hoped for in so thorough a report. It would be of considerable interest to know how many pounds of air per hour were furnished to the boiler during his test and the temperature and humidity of this air, also the analysis of the fuel oil and the resulting flue gases.

It would be of value to have presented additional figures giving the engine efficiency of the Doble uniflow engine rated in per cent based on the Rankine cycle, also steam consumptions per indicated and per brake horsepower-hours respectively, and a general comparison of fuel consumption per mile.

*The above discussion was contributed after adjournment of the meeting of the Metropolitan Section, at which the paper by Abner Doble was read and discussed. See May issue of THE JOURNAL.

Tractor Friction Transmissions

By CHAS. A. TRASK (*Member of the Society*)

INDIANA SECTION PAPER *Illustrated with* CHARTS AND PHOTOGRAPHS

A PAPER, entitled Tractor Transmissions, was read by E. R. Greer on Feb. 1 last at the Chicago Tractor Meeting of the Society. As an appreciable percentage of the tractors now in use are equipped with friction transmissions, a paper on the subject is incomplete without a description of the application of this type, and I have prepared this paper to supplement the one read by Mr. Greer.

If any two surfaces be placed in contact there will be noted a resistance in attempting to slide one against the other. Thus a block of wood, iron, or fiber lying on the table requires a greater force than the force of acceleration to move it. We may press our hands tightly together and a considerable exertion is necessary to slide one by the other. It is with this sliding friction that the so-called friction transmission deals.

We are familiar with the common belt and pulley drive in which there are no teeth or means of positive engagement between the belt and the pulley. It is a friction drive pure and simple, and at all times the belt slips or slides, however slightly, on the surface of the pulley. The resistance to this sliding makes it possible to transmit a load. There is also the ordinary cone clutch, the disk clutch, or the expanding shoe type, in which one driving surface is pressed tightly against another—the driven—and enormous loads are carried merely because of a resistance on the part of one member in sliding on the other. The locomotive drive wheel on its smooth steel rail; the automobile tire on a smooth pavement; brake shoes, brake lining, all these are friction devices. Their success depends entirely on the resistance offered by one member to sliding on the other member.

COEFFICIENT OF FRICTION

One material or substance, however, offers less resistance in sliding than another under the same condition; thus a block of fiber, rubber or cork on a smooth iron plate will require a greater force to move it than a similar smooth polished block of iron. In considering the friction drive it is necessary then to have a measure of the gripping tendency or, more properly, the resistance to sliding of one material on the other. This measure is called the *coefficient of sliding friction.* It represents a ratio of the resistance, in sliding one material on another, to the pressure with which they are held in contact. Thus if a block weighing 10 lb., placed on a smooth horizontal plate of iron, requires a pull of 5 lb. to move it at a uniform speed on the plate, then the coefficient of sliding friction for these two materials equals 0.5. Again, if the weight or pressure were 100 lb. the pull required to move it would be 50 lb. instead of 10; in other words, the resistance to sliding in any friction drive is proportional to the pressure under which the driving and the driven members operate. Probably most of us can better appreciate this condition from our familiarity with the ordinary belt drive, in which a greater tension in the belt produces a greater pressure on the pulley, enabling heavier loads to be carried. Likewise, a greater pressure of a brake shoe on a wheel, or a brake band on a drum, affords more resistance to slipping and more efficient braking action. There are then two important factors in any friction drive—*the pressure and the coefficient of friction for the two materials in contact.*

AREA OF CONTACT

An established law in physics is that the coefficient of sliding friction is independent of the area in contact. It does not matter whether the area of contact between two materials in a friction drive is 1 sq. in. or 100 sq. in., the area does not appreciably affect the resistance in sliding. With the belt drive, cone clutch, or brake band, this law holds equally true for all practical conditions. It is a mistake to consider that merely on account of greater area of contact, the wider belt, the wider brake band, or the wider face clutch will transmit more power. They will not, and the only reason for the increased area is to distribute better the pressure and the wear between their surfaces. In friction drives, we are interested in pressure alone.

POWER-TRANSMITTING CAPACITY

The type of friction drive with which this paper chiefly deals consists of two wheels—one fiber and the other metal—operated by having their rim surfaces pressed together along a line of contact and transmitting a pull due to the resistance of the driven member to sliding or slipping on the driver. If we know the pressure and the coefficient of friction in such a drive, then the product of the two will give the tangential pull. With any given drive the pull can be resolved into foot-pounds per minute, and dividing by 33,000 the horsepower transmitted can be determined. Thus:

$$Hp. = \frac{\text{(tangential pull, lb.)} \times \text{(tang. speed, ft. per min.)}}{33{,}000}$$

For a wheel D = Diameter in inches.

N = Revolutions per minute.

$$Hp. = \frac{\text{(tang. pull, lb.)} \times \pi D N}{33{,}000 \times 12}$$

$$= \text{(tang. pull, lb.)} \times 0.000{,}007{,}938\, D N$$

But tangential pull $= f \times P$

In which f = Coefficient of friction.

P = Pressure, lb.

In the most popular combination of friction materials (one wheel of cast iron and the other of tarred fiber) it is recommended:

*Experimental Engineer, Rockwood Manufacturing Company.

For spur, bevel, and miter drives (where faces have motion of true rolling contact) $f = 0.277$.

For variable-speed disk friction drives (where faces do not follow true rolling contact) $f = 0.323$.

Also it is recommended that a pressure not to exceed 250 lb. be used for each 1 in. width of face of fiber.

Then P (total pressure) $= 250\ w$, when w = width of face in inches.

Hence for spur, bevel, and miter drives:

$$Hp. = (0.277 \times 250\ w) \times (0.000,007,938\ D\ N) = 0.000,55\ D\ w\ N \quad (1)$$

And for disk drives:

$$Hp. = (0.323 \times 250\ w) \times (0.000,007,938\ D\ N) = 0.000,64\ D\ w\ N \quad (2)$$

As the power capable of being transmitted in friction drives varies directly with the pressure, it would be ideal to use friction materials with high compression strength. But it has been found that as a fiber material is increased in density to carry greater pressure, the coefficient of friction decreases. Therefore, as pressure multiplied by coefficient represents pull and as it is impossible to increase the value of one except at the loss of the other, no final gain results. *Pressure-withstanding quality of the fiber friction material is therefore the limiting factor in the friction drive.* If pressure is too high the structure of the fiber gradually yields and breaks down. This breaking down or disintegration at high speeds results in a charring or heating of the fiber; it becomes "brashy" and goes to pieces. Everyone knows the result of running on an under-inflated or over-loaded automobile tire; the wall fabric becomes sheared from the rubber, heat is generated and soon a new tire is needed. The effect of excessive pressure on a fiber friction wheel is very similar. It is absolutely necessary that pressures be kept within reasonable limits. The pressure of 250 lb. per in. of face width of fiber, given above, represents only about one-sixth to one-tenth the pressure that would break down the tarred fiber wheel for a short period of running, but for average long working periods 250 lb. is all that is safe, and even that may be high for rim speeds of from 6,000 to 10,000 ft. per minute.

Application of Pressure

The simplest and best method of applying the pressure between the friction surfaces would be through a foot pedal, or a lever that could be drawn up until the pressure is just sufficient to handle the load and then retained by suitable ratchet or pawl at any desired position. In every friction drive a greater pressure is required to start a load, owing to force required for acceleration and to the fact that the coefficient is less (100 per cent slip) than under normal running conditions. Also there will be times when overloads must be carried for a short time, as on short heavy grades, in sand, or when plows are dropped. The single pedal or lever permits the operator to readily meet all these conditions—just as a hand-controlled belt-tightener might be desirable to meet short overloads, so that the belt is not always operated under highly destructive tension.

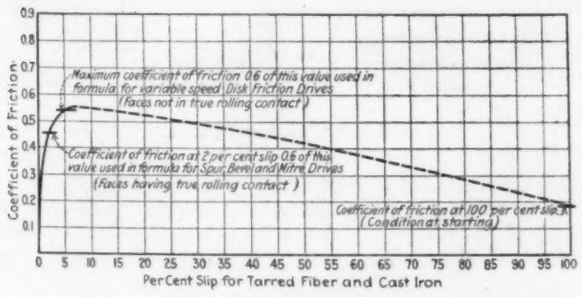

Coefficient of Friction
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Maximum coefficient of friction 0.6 of this value used in formula for variable speed Disk Friction Drives (faces not in true rolling contact)
Coefficient of friction at 2 per cent slip 0.6 of this value used in formula for Spur, Bevel and Mitre Drives (Faces having true rolling contact)
Coefficient of friction at 100 per cent slip (Condition at starting)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Per Cent Slip for Tarred Fiber and Cast Iron

Fig. 1—Relation Between Coefficient of Friction and Slip in a Friction Transmission

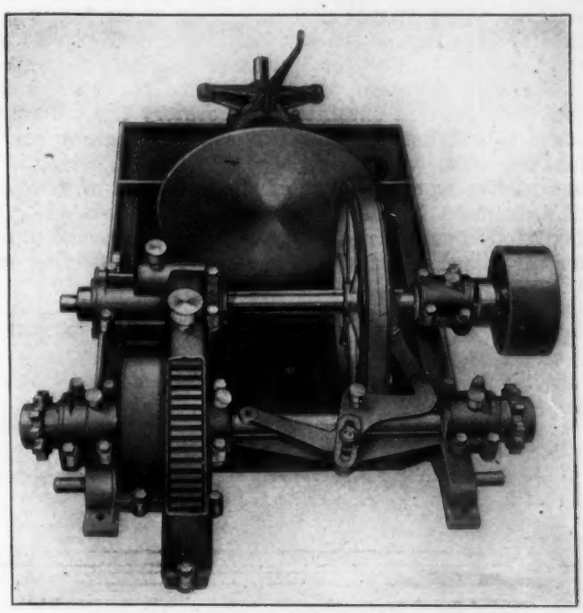


Fig. 2—Disk Friction Drive of the Elgin Tractor

Industrial and farm vehicles are frequently placed in the hands of those whose muscular development exceeds their mental development and it is necessary to either educate the driver in order to obtain approximately the correct pressure or make the drive foolproof to guard against his lack of mechanical sense. Hence for tractor service it seems advisable to consider the independent application of a fair operating pressure under normal load conditions and then provide auxiliary means to obtain greater pressure for short periods, as the operator may find the conditions to warrant. This arrangement can be carried out through a lever or arm controlled by a spring, which will always operate the friction members under a fair average pressure when engaged (just as is the ordinary automobile clutch), an auxiliary lever or pedal to be provided without ratchet or stop, to be effective only so long as the operator exerts pressure through them. In any event, while sufficient pressure is necessary to operate the friction drive without undue slip, at the same time practically all the trouble encountered is caused by excessive pressure, and some guard must be provided against its continual use. Like the belt drive, the ordinary friction drive operates with only a small percentage of slip, and any operator soon becomes able to tell if this becomes excessive.

Slippage

Fig. 1 shows a curve representing a typical relation existing between coefficient of friction and the slip between the driving and the driven wheels. This relation is quite similar to that holding true for the ordinary pulley and belt drive. Starting at zero per cent slip the coefficient of friction (or the resistance to slipping) in-

creases and reaches a maximum at about 6 per cent slip. This is the point of maximum pull; from then on the coefficient decreases again until at 100 per cent slip it is only about one-third that at 6 per cent. The common practice is to design a belt drive for a value of the coefficient corresponding to 2 per cent slip. Likewise 2 per cent slip is used in designing friction drives having spur, bevel, or miter shapes and where the faces follow motions of true rolling contact. At 2 per cent slip on the curve the value of the coefficient of friction as shown is about 0.462. However, the curve represents values under ideal conditions as obtained in laboratory test. To provide a fair factor of safety for average working conditions the actual value is reduced 40 per cent, giving as a conservative working value of the coefficient of friction, 0.277, as used in the calculations for formula (1). In disk friction variable speed drives, it is impossible to design for a fixed percentage of slip between the driving and

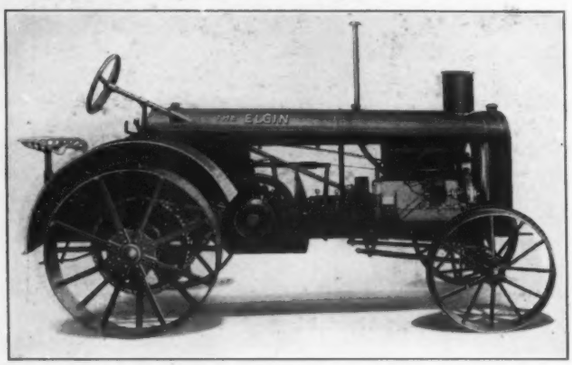


FIG. 3—SIDE VIEW OF THE ELGIN TRACTOR

the driven members, as a slight twisting action always occurs on the wheel face, owing to the lack of true rolling contact, and the actual slip varies with the different positions of the wheel on the disk. The tendency in this arrangement of drive is for the slip to increase until, for the different points on the face, the total average value corresponds to the value of the coefficient just sufficient to carry the load under the pressure being used. Naturally for greatest transmitting capacity this is represented by the values at the peak of the curve. Therefore, it is customary to design disk drives on the basis

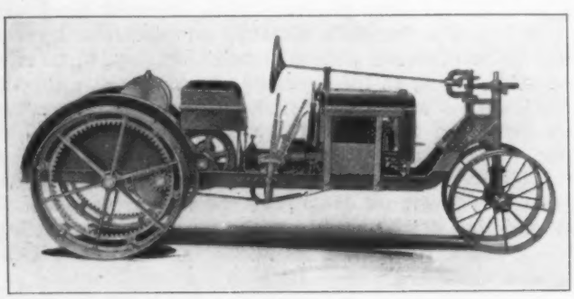


FIG. 4—SMALL AVERY TRACTOR

of average maximum values. In the case of the curves shown in Fig. 1 a fair average maximum value of the coefficient is 0.54 and 60 per cent of this, taken as a fair working value, is 0.323, as used in formula (2).

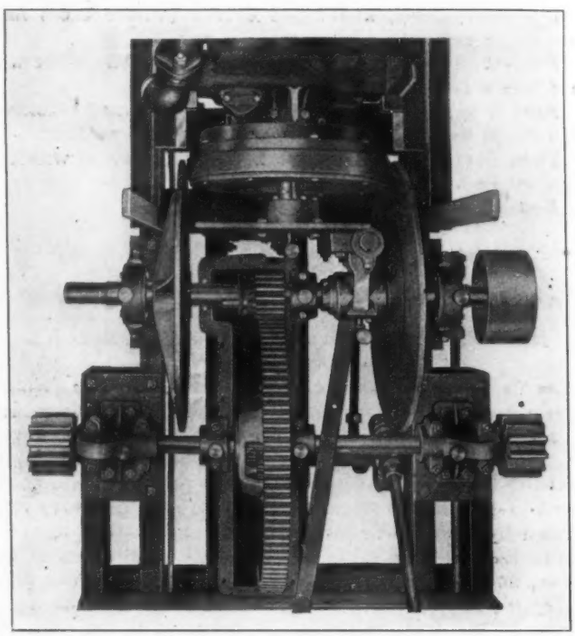


FIG. 5—DOUBLE-DISK TRANSMISSION OF THE HEIDER TRACTOR

Between values of 6 and 100 per cent slip (shown by the broken line) the relations on the curve are assumed. These no doubt are approximately correct, and in any event the values within these points do not materially affect practical operating conditions. The reduced value

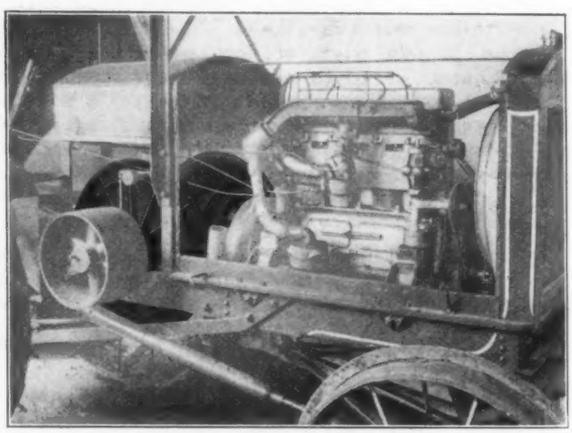


FIG. 6—PORT HURON TRACTOR

of the coefficient at 100 per cent slip explains why, for a given fixed load a proportionally higher pressure is required at starting and also why this condition is independent of the pull needed to accelerate the load from rest.

OPERATING SPEEDS

Since power is merely the rate of doing work, and any given friction has a fixed maximum tangential pull corresponding to the pressure of contact and the coefficient of friction, the power-transmitting capacity of friction drives varies directly with the speed of operation. There

FIG. 8—SQUARE TURN TRACTOR. IN STOPPING POSITION AT THE LEFT, STARTING POSITION AT THE RIGHT AND TURNING IN THE CENTRAL VIEW

appears to be no particular limit to the safe operating speeds of friction wheels, such drives having been operated at rim speeds up to 13,000 ft. per minute, but for average conditions the surface speed may be anything up to 6000 or 8000 ft. per minute.

POINTS ON DESIGN AND INSTALLATION

In the case of variable speed disk drives, these surface speeds should be obtained by the use of disks of large diameter rather than by high rotating speeds, so that in low-gear position the friction wheel will reach such a point on the disk that the surface speed will be moderate. For this reason, the operator should slow down his engine when starting the load so that when the surfaces are engaged there will be less slip to overcome and less wear of the friction surfaces as a result.

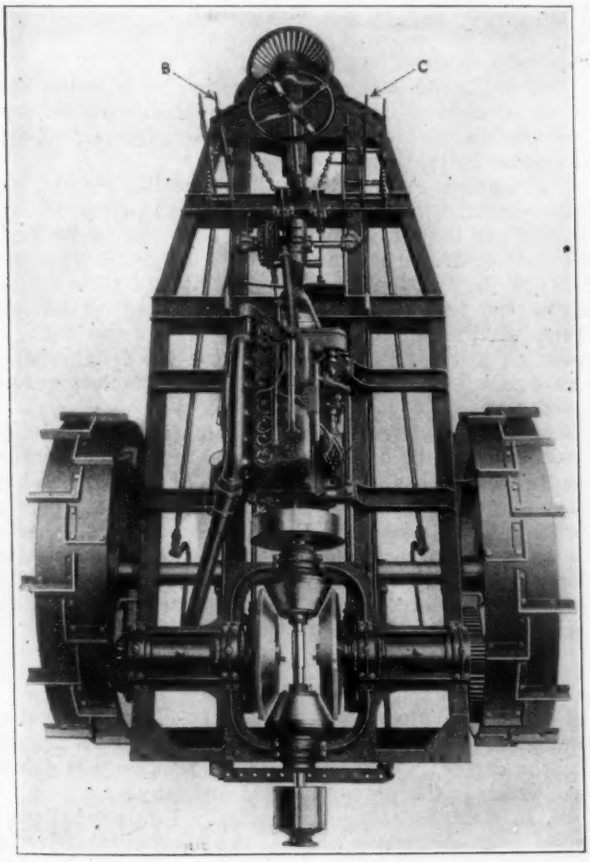


FIG. 7—FRICTION TRANSMISSION OF THE SQUARE TURN TRACTOR

In mounting friction transmissions, the speeds usually being high, it is well to see that all parts are properly balanced. Ball or roller bearings, both radial and thrust, of the self-aligning type, or bearings mounted in self-aligning housings, should be used to compensate for possible springing or deflections of the shafts, and for distortions owing to road inequalities. This point is important as otherwise bearing trouble may develop. The average designer appears to consider that his shafts are called upon to transmit only a given torque. In friction drives they must also carry the pressure and maintain the correct alignment of the faces of the friction members. Actual operating conditions are not those of the erecting floor; design ample bearings and shafts, arrange to protect the friction surfaces from dirt and oil, make friction members of sufficient size to require only reasonable pressure, and then let the user know at least the basic principles of the drive which he is to operate. If this is done the drive will be successful, and will be just as dependable as any belt, chain and sprocket or toothed gear drive. If the drive fails to handle its load or wears badly, do not blame the transmission, when the fault is due to inadequate size or to improper installation. There is a real advantage to the tractor in the extreme simplicity, the flexibility, the soft velvet clutching action, and the high efficiency of the friction transmission. It means longer life of the entire machine, greater ease in handling, and more work done per gallon of fuel.

FRICTION TRANSMISSION TYPES

Fig. 2 shows a simple form of disk friction drive mounted in a substantial frame, as applied to the Elgin tractor. Three pins projecting from the engine flywheel engage the spider that drives the disk shaft. The pressure is applied through the lever shown. Six forward positions and a reverse are provided, thus permitting the engine to work at its best speed regardless of the load. When used for stationary power purposes the pinion on the countershaft is disengaged by pulling the button shown above the left-hand bearing.

Fig. 3 shows the complete Elgin tractor, which weighs 3300 lb. Its speed reduction is 35 to 1 on high, 140 to 1 on low and the rear-wheel diameter is 42 inches.

Fig. 4 shows the small Avery, a tractor of similar type. Large numbers are in use on farms and for a wide variety of other purposes.

Fig. 5 illustrates the double disk transmission on the Heider tractor. In this arrangement the fiber friction member is a part of the flywheel; both disks are keyed to the countershaft, which slides endwise to bring the disks into frictional contact with the fiber, being moved to

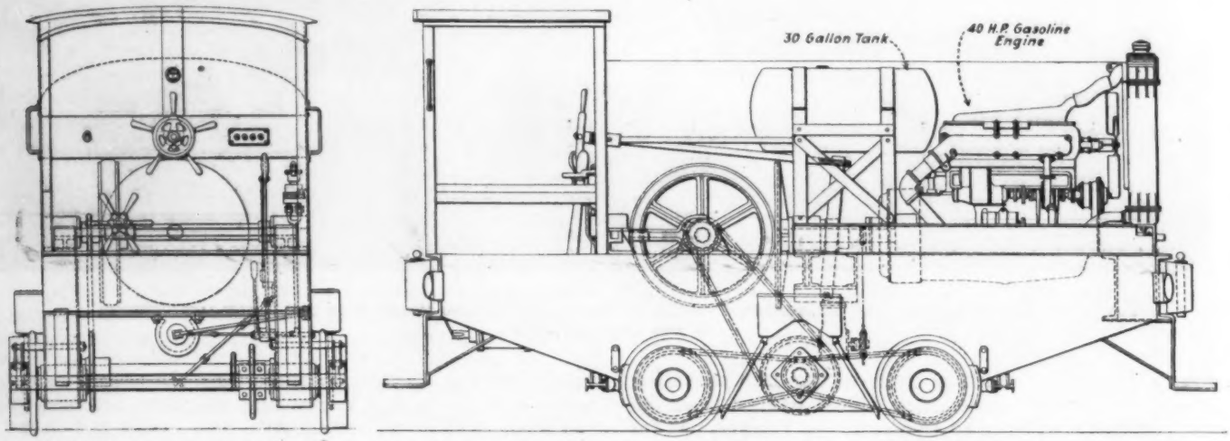


FIG. 9—CUMMINGS SIX-TON LOCOMOTIVE, END AND SIDE ELEVATIONS. THE FRICTION TRANSMISSION MEMBERS ARE BROUGHT TOGETHER BY SCREW PRESSURE

the right to go ahead and to the left to back. To increase speed the engine, and with it the fiber friction wheel, is moved toward the center of the disks. Seven speed positions are provided. The rear end of the crankshaft is carried in a ball bearing. The engine is 32 hp. The tractor weight is 6000 lb. This machine has been built for ten years and large numbers are in use. The National tractor, photo of which I was unable to secure, has a similar transmission arrangement. Fig. 6 shows the transmission in the Port Huron tractor. This is similar to the Heider, but instead of moving the engine when changing speeds the friction wheel slides on the rearward extension of the crankshaft.

The Square Turn tractor, a mechanical acrobat, is shown in Fig. 7. Only one speed reduction is provided. The levers, *B* and *C*, operate eccentrics carrying the large bevel friction wheels. The operator can cause both road wheels to go forward or backward, or one to go back and one forward at the same time. The machine has a single

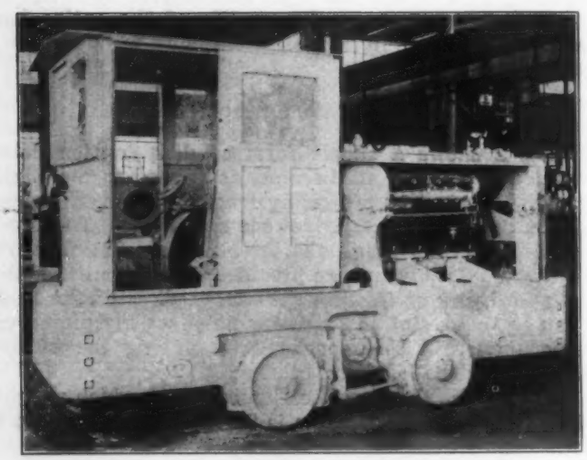


FIG. 10—WHITCOMB EIGHT-TON LOCOMOTIVE

castor wheel at the narrow end; this is the rear end when plowing, the plows being underneath. When towing, the driver's seat is swung around to the opposite side of the steering wheel, the driving wheels then being in the rear. No differential is required. The machine weighs 7800 lb. and has 70-in. driving wheels and a 40-hp. engine. Fig. 8 shows self-explanatory views of the same machine in the field. After reaching the "stop" position the driver reverses the left-hand wheel until the machine has made a right-angle turn.

Fig. 9 shows how the friction transmission members of the Cummings 6-ton locomotive are brought together by screw pressure, the screw being operated by a hand-wheel. The disk and friction wheels are 28 in. diameter. A number of these are now being built for the Government ordnance departments. The driver must be taught to lessen the pressure after getting his train under way or the fiber wheel will be short-lived. The speed change in this drive is obtained by the use of rack and pinion.

The Whitcomb 8-ton locomotive is shown in the shops of its builders in Fig. 10. I was unable to obtain drawings of this machine. The general arrangement of drive is similar to that of the Cummings.

The builders of the Plymouth locomotive, Fig. 11, have been constructing friction-transmission equipped commercial and industrial vehicles for eleven or twelve years. On friction-driven locomotives it is the usual practice to arrange the friction wheel so that it will slide entirely across the face of the disk in order to give the same speed whether going forward or back (see Fig. 12), while on tractors it is usual to move the friction wheel past center only enough to obtain a satisfactory reverse speed, which is usually fairly slow.

A noiseless universal coupling, in which four flexible blades connect the driver on the end of the disk shaft to the flywheel is shown in Fig. 14. This device has been thoroughly tried out; it permits sufficient end-play so that the friction surfaces may be brought together or disengaged. It needs no center bearing, does not wear and is cheap. Fig. 15 shows a type of split filler or fiber band which is especially convenient for making repairs without disturbing other parts of the mechanism.

THE DISCUSSION

GEORGE A. WEIDELY (M. S. A. E.):—I noticed that on some of the tractors illustrated the fiber friction member was the driver. On others the fiber friction was driven. Just which is the proper method and why?

W. D. HAMERSTADT:—Theoretically I do not believe it makes much difference whether the fiber wheel drives or is driven. One practical condition, however, that enters is the wearing of flat places on the fiber. That can occur

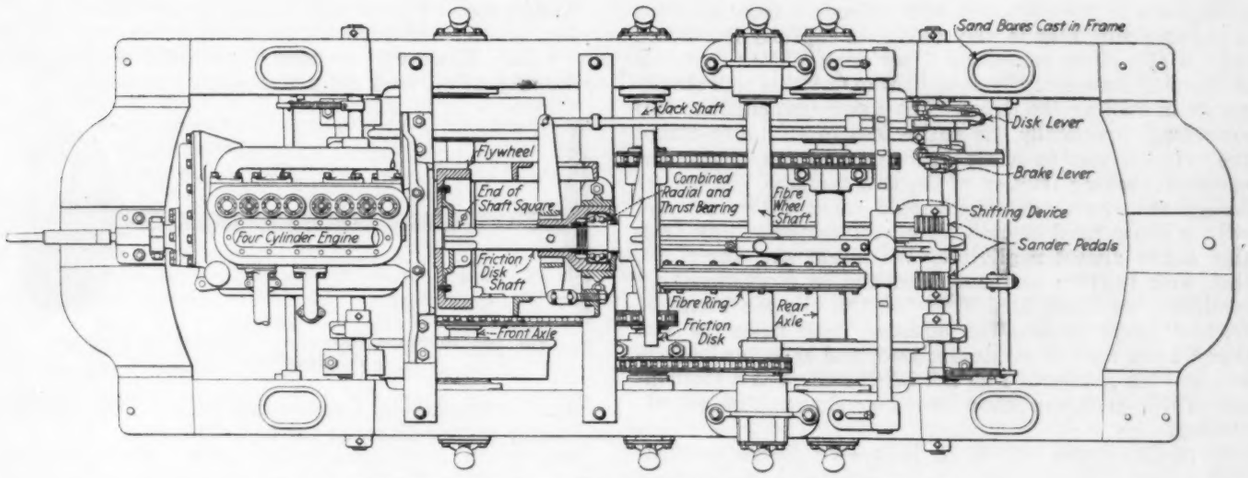


FIG. 11—PLYMOUTH LOCOMOTIVE, PLAN VIEW, SHOWING THE FRICTION DRIVE

only when the fiber wheel is driven. Although such trouble constitutes one of the principal talking points against the friction drive, as used in automobiles, it does not occur as much as people may think. I have operated friction drive cars very extensively with the fiber driven member and never encountered such trouble.

Service Differs on Tractors and Automobiles

In tractor designs where there is a relatively great speed reduction through the friction members, the large diameter metal disk used as a driven member seems to work out best. I believe, however, the most important consideration is the nature of the work. Tractors operate by far the greater part of the time at low speeds and under the heaviest loads, as in plowing. Now, the highest efficiency in the variable-speed disk friction drive is when the fiber wheel is at the outermost point of the diameter of the disk. Therefore, to obtain highest efficiency during the period of greatest work and when most needed, as on heaviest pulls, I would recommend the fiber as the driving member. The condition is exactly reversed with automobiles; most of the service is on high speed with light loads. For such service I would recommend the fiber member as the driven. Of course, in either case the ability of the transmission to handle its load should be at all times equal to the capacity of the engine.

Slippage and Coefficient of Friction

D. L. GALLUP (M.S.A.E.):—What is the reason for the coefficient of friction of spur, bevel and miter gear drives being less than for variable speed drives?

MR. HAMERSTADT:—The point has been brought out by Mr. Trask. Spur, miter, and bevel drives have a motion of true rolling contact between their faces, and, like belt drives, they are designed for a uniform constant slip of say 2 per cent. The value of the coefficient of friction for such drives is, therefore, that value corresponding to 2 per cent slip on the slip-coefficient of friction curve (after deducting 40 per cent as a factor of safety for actual working conditions). In disk friction drives there is a certain twisting action of the fiber wheel against the face of the disk, and for each different position of the fiber wheel on the face this twisting action and the total average slip varies. Taking a case in which the slippage on the fiber is 4 per cent at a point near the center of the face of the disk, 3 per cent at a point midway between the center and outer edge of the fiber, and 2 per cent on the outer edge, each of these points will be pulling with a different value of the coefficient of friction corresponding to its rate of slip on the slip-coefficient of friction curve. As the load increases there will be a tendency for each point to slip more, so as to have a greater pulling capacity. A glance at the slip-coefficient of friction curve readily shows that the different points with their varying slippage exert maximum pull only as the slips approach values corresponding to maximum coefficient values at the peak of the curve, say 6 per cent slip. This average maximum value of the coefficient of friction is used, therefore, as the basis of design for variable-speed friction drives, of course, after allowing the 40 per cent factor of safety. It is not based on a predetermined fixed value of slip as for spur, miter and bevel drives.

MR. GALLUP:—I supposed that spur, bevel, and miter drives were more efficient?

MR. HAMERSTADT:—They are more efficient than variable-speed drives. However, that statement may lead one to underestimate the efficiency of the variable-speed drive, whereas it is very good. The curve shows that the maxi-

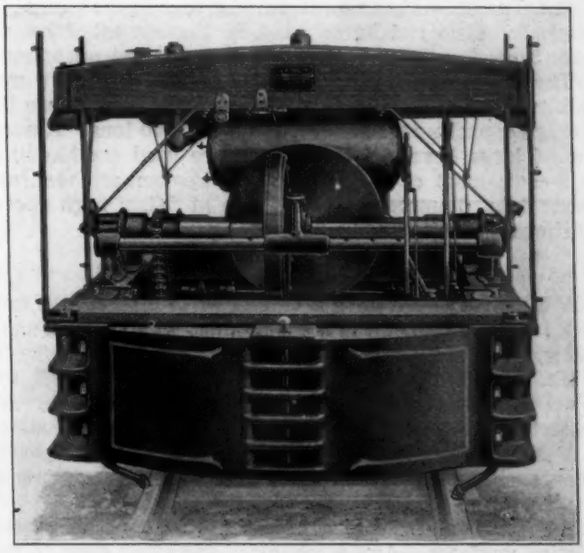


FIG. 12—PLYMOUTH LOCOMOTIVE, REAR VIEW, SHOWING PROVISION FOR SLIDING THE FRICTION WHEEL ACROSS THE FACE OF THE DISK

mum value of the coefficient of friction is reached at about 6 per cent slip, that is, the maximum capacity is reached with a slip never exceeding 6 per cent. After that, the decreasing values of the coefficient of friction will simply result in stalling the drive. The 6 per cent slippage loss represents practically the entire loss in efficiency except the friction loss in shaft bearings and the slight loss caused by rolling friction of the two surfaces. In proper design the shaft bearings should cause little loss and with a dense hard smooth fiber surface the rolling friction seems almost negligible. We might say, therefore, that with friction surfaces clean and in good operating condition, as must hold true for the slip-coefficient of friction curve shown, the efficiency will never be less than 94 per cent at maximum load, and at lower loads it will be even greater. I do not believe there is a toothed-gear drive that can show continuously as high an efficiency.

C. S. CRAWFORD (M. S. A. E.):—We design toothed-

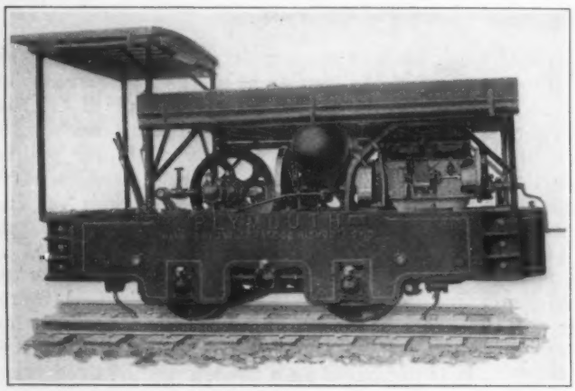


FIG. 13—PLYMOUTH LOCOMOTIVE, SIDE ELEVATION

gear drives to transmit power as efficiently as that but they are not manufactured that way.

MR. GALLUP:—What is the maximum commercial capacity, in horsepower, of a friction drive?

MR. TRASK:—I do not think it has ever been reached.

MR. GALLUP:—Two thousand horsepower?

MR. TRASK:—I see no reason why that figure cannot be reached. I do not know what is the largest drive we have turned out, but 5-in. shaft sizes are not uncommon.

The Panama Canal Commission has installed machinery for handling coal at Balboa and Colon where the storage capacity is, I believe, about 900,000 tons. A number of large bevel friction drives are used for handling this coal; most of the shafts, as I remember them, are about 5 in. diameter and they run at fairly high speed. I believe the units handle 3000 tons per hour.

Protection of the Friction Members

A MEMBER:—We have a tractor with a straight-faced disk. What provision is made against trouble from sand and grit?

MR. TRASK:—The friction members are not left exposed as shown in the illustrations. Generally they are protected just as carefully as toothed-gear transmissions.

A MEMBER:—Is there any difference in the capacity when such a drive is inclosed, particularly when grease or oil gets on it? How does lubricant affect it?

MR. TRASK:—Oil and grease must be kept off of the friction surfaces. Any mechanism operating close to the friction surfaces can be shielded in some way to prevent throwing lubricant.

A MEMBER:—Should the surfaces be absolutely dry?

MR. TRASK:—They should be shielded from road splash and rain. However, we have found that a very small sprinkling of oil does not cause much harm.

FIG. 14—NOISELESS UNIVERSAL COUPLING FOR FRICTION TRANSMISSIONS

MR. CRAWFORD:—Are compounds of any kind used occasionally on the disks, as for belt drives?

MR. TRASK:—We have experimented with dressings but it has been found that best results obtain from incorporating a small amount of compound in the fiber when it is being made.

Friction Wheels Operate Better in Damp Weather

MR. HAMERSTADT:—A fiber friction wheel invariably operates better in damp weather. It seems to pull more owing to the fact that the material absorbs moisture. Any friction dressing must, therefore, be hygroscopic in nature. The moisture absorbed seems to toughen the fiber. Rosin or greases should never be used. In the presence of heat due to slippage, the rosin will melt and then cause slippage. Oil and grease soak into the fiber, reduce the coefficient of friction and cause a high rate of slippage. After becoming absorbed it is almost impossible to get them out.

MR. CRAWFORD:—Have devices ever been applied to these tractors for truing the fiber member in case flat spots or anything of that kind should develop?

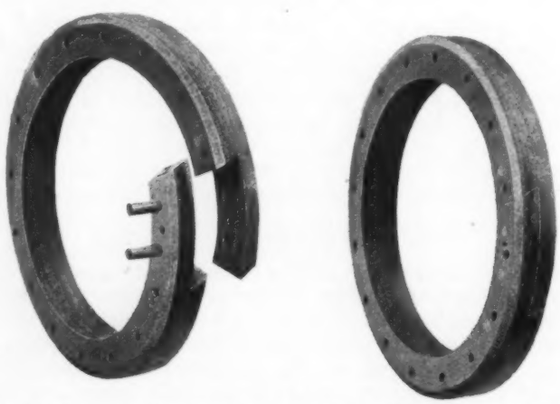


FIG. 15—SHOWING CONSTRUCTION OF A SPLIT FILLER OF FIBER BAND FOR A FRICTION TRANSMISSION

MR. HAMERSTADT:—That used to be brought up as advisable for automobile friction drives, but I never heard of it or the need of it for a tractor. I can see no real commercial need for that attachment on the machine. The friction rings are made with a split lap, and one of those wheels can be replaced in a half hour.

Comparison with Belt Drive

MR. WEIDELY:—This friction drive has been likened to a belt a number of times, and I do not see the simi-

larity. A friction drive depends upon certain contact pressure, and Mr. Trask made the statement that it did not require any considerable area of contact. A tight belt is not required in a belt drive, but smooth surfaces and many square inches of belt contact are needed. According to Mr. Trask these are not needed in a friction drive.

MR. HAMERSTADT:—I can probably answer Mr. Weidely by asking a question: Why is a Gabriel snubber effective?

MR. WEIDELY:—Because of the number of wraps around the pulley.

MR. HAMERSTADT:—The belt drive is similar to the Gabriel snubber. An enormous pressure is introduced against a body by taking one or more wraps around it with a cord or band and then pulling on the cord. We all know the effectiveness of the cable drum or winch. Area absolutely is not required in a belt drive to transmit power, but we do need the wrapping pressure of the belt against the pulley face just as in the Gabriel snubber. A belt one inch wide will transmit the same power to a pulley as one ten inches wide if they both have the same arc of wrap, the same tension and the same speed.

A MEMBER:—Then why is compound used on a belt?

MR. HAMERSTADT:—A compound or dressing applied to a belt will increase the grip or value of the coefficient of friction between the surfaces. Of course, if we can increase the value of the coefficient of friction, then for a given pull the pressure need not be so great, and likewise the tension in the belt that causes the pressure may be less; in other words, belt dressing will permit a slacker belt, so long as its effect lasts.

MR. CRAWFORD:—The most satisfactory belt drive, however, is with a slack belt having a large arc of contact on the pulley.

MR. HAMERSTADT:—Yes; if the arc of wrap of the belt is great, it results in a much greater total pressure of the belt on the pulley, and, of course, the power that can be handled is dependent on this pressure.

Friction Drive Rim Speed

A MEMBER:—Is there a definite speed at which the friction drive members should operate? Will it give extra efficiency or under efficiency or burn itself up by going too fast?

MR. HAMERSTADT:—I know of no particular limit. Friction surfaces can and do commonly operate at speeds of 6000 to 7000 ft. per min. Of course, for a given amount of power, the higher the rim speed the less the tangential pull, and therefore less pressure is required between the friction members. Like the belt drive, it is economy to operate at high speeds. I have known of frictions to operate at speeds as great as 13,000 ft. per min., as mentioned by Mr. Trask, but this seems too high. In any case, as the speed increases, the pressure on the friction surfaces should be reduced, as otherwise the "flexing" or "working" of the fiber at the high speeds will generate excessive heat and do damage.

GEORGE T. BRIGGS (A. S. A. E.):—Should there be a definite size depending on the amount of load? Are there varying sizes of fiber wheels?

MR. TRASK:—There are no fixed stock sizes of friction wheels. Any size within the limits of mechanical construction can be supplied and by following formulas which I have given any engineer can tell what size to use.

A MEMBER:—If it is desired, with a belt drive, to double the power transmitted at a given speed by two members (one driving and one driven) the width of the belt could be increased. What is done with a friction drive for a similar case? Is the pressure or the width of the driving disk increased or what is the limiting factor?

MR. TRASK:—The surrounding conditions govern that. If space were available they might be increased in diameter. In a belt drive the diameter of pulley or width of belt can be changed. In a friction drive the diameter of friction or its width of face can be increased.

MR. HAMERSTADT:—Let me point out in this connection that to increase the width of belt or the face of the friction members does not in either case, in itself, result in greater transmitting capacity. Belt widths are increased so that the total section of the belt will be sufficient to stand the tension under which it must operate, without too great a stretch; in other words, to increase the thickness of a belt will have just as much effect as to increase its width. Likewise, the face widths of friction members are increased only to give a proper distribution of the total pressure necessary to handle the load. In all cases it should be remembered that it is not safe to apply more than a certain fixed pressure against each one-inch width of face and greater total pressures can be safely used only by increasing the face widths. Pressure in friction drives and belt tension in belt drives are really the important limiting conditions of these forms of transmission. Use of excessive pressures will invariably result in rapid breaking down and destruction of the fiber.

RURAL MOTOR TRUCK EXPRESS

THREE outstanding facts demand that especial attention be given to the increased use of the highways for rural transportation:

1. The increased volume of foodstuffs to be hauled.
2. The need for more labor on farms.
3. The need to encourage local food production.

Purpose of Rural Motor Express

The motor truck has demonstrated its adaptability to the hauling of farm products. It is dependable wherever the roads are capable of carrying its load. The use of the motor truck for farm transport is growing rapidly and in the vicinity of many cities regular routes are now maintained.

By "rural motor express" is meant the use of the motor truck in regular daily service, over a fixed route, with a definite schedule of stops and charges, gathering farm produce, milk, live stock, eggs, etc., and delivering them to the city dealer and on the return trip carrying merchandise, machinery, supplies, etc., for farmers and others along the route. This service amounts to a collection and delivery that comes to the farmer's door with the same regularity that the trolley car passes over its tracks.

Plan of Organization

The Council of National Defense, by a resolution adopted March 14th, "approves the widest possible use of

the motor truck as a transportation agency, and requests the State Councils of Defense and other State authorities to take all necessary steps to facilitate such means of transportation, removing any regulations that tend to restrict and discourage such use."

The highways transport committee of the Council of National Defense is charged to carry out the purpose of this resolution. The several state councils of defense have been asked to appoint highways transport committees, or to delegate the organization of rural express to some committee which will have charge of the development of the work within the state. These state committees will in turn further the work through local organizations.

The Post Office Department has demonstrated the value of motor-truck transportation through experimental lines of parcel-post trucks now in operation in several of the eastern states. Several other Government agencies have endorsed the plan.

The preliminary surveys by the highways transport committee in sections of Maryland and Virginia have shown that farmers and merchants enthusiastically indorse the plan and wherever rural motor express lines have been properly developed they have received the support of the communities which they serve.

Present Development of Rural Express

The rural express is in successful operation in the vicinity of many of the larger cities. The development of this system of transportation has been particularly rapid in Maryland.

A detailed survey was made of 22 routes, leading from agricultural sections into Baltimore, Md., and Washington, D. C. On these routes 30 trucks were found in operation; the total capacity of these trucks was 73 tons; the mileage traversed daily was 1574 miles; the average length of the routes was about 50 miles for the round trip. Most of these routes are operated by truck owners living at the outer terminal, making daily round trips into the marketing center. Many of these routes are operated by farmers who first learned the advantages of motor-truck transportation by using trucks for their individual needs.

These lines have been developed on a sane, practical basis without any special promotion or encouragement from any state or national organization. These lines have developed chiefly on the roads of the state road system where the condition of the roads facilitate the use of trucks. Many farmers living short distances away from the rural express route bring their milk and produce to a point on this route with horse-drawn buggies and wagons and these constitute feeders to the lines.

A preliminary survey for the State of California has been made, showing an extensive use of motor trucks for passenger, freight and express hauling throughout that state. Over 136 separate lines were found, some traversing routes as long as 125 miles on daily trips. Large quantities of farm produce are handled, and charges are made according to published rates. The excellent highways of California made it possible for these lines to develop rapidly.

The detailed survey among patrons of a number of these routes discovers the fact that there are three great economic advantages in this method of transportation:

1. Food production is stimulated since the regular outlet to market encourages many farmers to expand production which they would not be justified in doing if they were obliged to transport their own produce to market.

2. Shortage of labor is greatly offset from the fact that the system leaves the farmer on the farm and his time is not consumed in trips to market.

3. There is immediate improvement in the efficiency of the farm since supplies, machinery and repairs can be secured promptly from city distributers of fertilizers and farm machinery.

From the national standpoint these routes aid in several ways:

1. They relieve the railroads of local freight, which permits carload lots of materials and foodstuffs from distant points to enter the terminals.

2. They help to avoid the necessity for local freight embargoes.

The need for the system of carrying goods to market without requiring men and teams is generally recognized by farmers, and where production of the individual farmer has justified the purchase of a motor truck, the adoption has been very rapid during the past few years. On many farms, however, the quantity of production is not sufficient to justify the investment in a truck by the individual farmer if he must maintain his teams for farm power. The use of the rural express with its greater speed enables the farmer to operate the same or an increased acreage with fewer horses, making more land available for food production which was previously needed to grow grain and hay for teams. In many instances, the introduction of rural express has enabled farmers to engage in the production of milk, which requires daily marketing.

The rural express greatly aids the country merchants in carrying more complete stocks of goods; in filling special orders promptly and in avoiding temporary shortage of staples due to delayed shipments or embargoes on the railroad. In many instances the country merchants have reported that their business has been greatly improved because of the daily delivery service from wholesale centers.

Expansion to a National System

The success of existing lines of rural express is convincing evidence that the expansion of the system is an immediate necessity, both for its value in meeting the present emergency and as a means of permanently improving rural transportation. What has already developed becomes an integral part of our national transportation system.

The rural motor express is not, however, a development to meet an emergency only, but rather an expansion of transportation facilities to meet the growing demands, to bring the consumer in closer touch with the producer; to relieve the producer of the burden of marketing his produce and permit him to remain on the land where his labor is of highest value to the community.

Organization of New Routes

The state highways transport committees are organizing local committees in all communities where there appears to be the need for improved rural transportation. The local committee first secures co-operation of the local press and leading organizations interested in transportation and food supplies. Among the various groups who might be interested are the following: Chambers of commerce, boards of trade, merchants' associations, local food administrators, farmers' clubs, county agricultural agents, dealers in farm implements, feed, fertilizers, grain, and other farm produce.

Meetings of the representatives of these organizations

are held to explain the plan of rural express and to make general survey of local needs.

After a general survey of the country or district has been made the local committee conducts an intensive survey by means of mailed questionnaires or personal visits among farms and merchants along the route of prospective lines.

When the desirability of establishing a new route for a certain section has been determined the committee proceeds to consult owners of trucks, farmers and other private owners to locate a man to establish the route.

Detailed suggestions on conducting these local surveys, methods of making surveys through questionnaires, questions concerning roads, charges, etc., will be furnished by the highways transport committee of the Council of National Defense through the state committees.

GOVERNMENT COMMISSION TO STANDARDIZE SCREW THREADS

ON May 8 a bill (No. 10852) to provide for the appointment of a commission to standardize screw threads passed the House of Representatives in the form in which it was reported by the House Committee on Coinage, Weights and Measures. The bill was originally introduced by Mr. Tilson, representative from Connecticut, in the following form:

> Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That a commission is hereby created, to be known as the Commission for the Standardization of Screw Threads, hereinafter referred to as the commission, which shall be composed of five commissioners, one of whom shall be the Director of the Bureau of Standards, who shall be chairman of the commission; one a commissioned officer of the Army, to be appointed by the Secretary of War; one a commissioned officer of the Navy, to be appointed by the Secretary of the Navy; and two to be appointed by the Secretary of Commerce, one of whom shall be chosen from nominations made by the American Society of Mechanical Engineers and one from nominations made by the Society of Automotive Engineers.
>
> SEC. 2. That it shall be the duty of said commission to ascertain and establish standards for screw threads, which shall be submitted to the Secretary of War, the Secretary of the Navy, and the Secretary of Commerce for their acceptance and approval. Such standards, when thus accepted and approved, shall be adopted and used in the several manufacturing plants under the control of the War and Navy Departments, and, so far as practicable, in all specifications for screw threads in proposals for manufactured articles, parts, or materials to be used under the direction of these departments.
>
> SEC. 3. That the Secretary of Commerce shall promulgate such standards for use by the public and cause the same to be published as a public document.
>
> SEC. 4. That the commission shall serve without compensation, but nothing herein shall be held to affect the pay of the commissioners appointed from the Army and Navy or of the Director of the Bureau of Standards.
>
> SEC. 5. That the commission may adopt rules and regulations in regard to its procedure and the conduct of its business.
>
> SEC. 6. That the commission shall cease and terminate at the end of one year from the date of its appointment.

There was an extended debate on the bill. In explaining the need for a standard of tolerances, Mr. Tilson said:

"The question is as to how far from the line of perfection, which is unattainable in all terrestrial things, should the manufacturer of screws be permitted to deviate in order to enable him to manufacture them commercially. You will understand that if you require an impossible standard or attempt to approximate too closely to perfection, it simply impedes production, without any corresponding gain in utility. You cannot proceed with the manufacture of an article unless a proper allowance is made, or, as it is usually called, a commercial allowance.

"For a number of years the subject of screw-thread tolerances has been under discussion by engineers and manufacturers of articles from metal. The two societies mentioned in this bill have gone about it, each independently working at the problem. Finally they conferred together, and have come to Washington asking that Congress authorize the establishment of a commission. It is confidently believed that such a commission will be able to bring together the data already gathered by these societies, by the War and Navy Departments, and by others, and determine the proper standard of screw-thread tolerances in the manufacture of screws.

"In determining the proper allowances in the manufacture of screws there are five different things to be standardized. First is what we call the lead; that is, the number of threads per inch. Then there is the angle; that is, the angle between the threads. Then there are the diameters. Three diameters are required—first, the outside diameter from the crest of the screw thread to the crest on the other side; second, what is called the root diameter, from the bottom of the thread to the bottom of the thread on the other side; third, and a very important item, is the pitch diameter, which is measured from the center of the thread on one side to the center of the thread on the other side.

"It is provided that after the commission has determined what the proper standards are the Secretary of Commerce shall promulgate the standards, have them printed as a public document, and thereafter it shall be required in all Army and Navy specifications that those standards shall be put into the specifications. There is no penalty and if private manufacturers do not wish to use it they do not have to do so, except in work they do for the Government.

"Private manufacturers, however, desire this done just as much as anybody else. They would like to have the standard of tolerance for screw threads uniform all over the United States."

HEADLAMP REPORT OF ILLUMINATING ENGINEERING SOCIETY

AT the organization of the Illuminating Engineering Society's Committee on Automobile Headlamps, it was instructed to elucidate and summarize such scientific and technical data on the subject of automobile headlamps as would be likely to be of service to other committees in drawing specifications or in drafting legislation. The nature of the matter available and the uses to which it was to be put were such that the committee found it advisable to prepare data for two different objectives: (1) the designing of headlighting systems and (2) the framing of legislation to regulate headlighting. This committee has left to other committees the reduction of the principles of headlighting to details of practice or to the form of legislative enactments.

A report of this committee was recently submitted to the Illuminating Engineering Society and is now available in printed form. This report is in five sections, the first being introductory. Since headlighting requirements must be based on the properties of the human retina in reacting to light, the report gives in Section II on The Requirements of Vision a summary of what is known of the essential, desirable and tolerable in the intensity, direction and color of the illumination provided by headlamps. The technical optics of beam lighting to produce the light required for vision within certain limits of tolerance is summarized in Section III on The Optical Principles of Headlighting. The Principles of Practical Headlighting are summarized in Section IV in which various classes of controlling devices are discussed in relation to their optical properties. Legislation, however, must be based not only upon ideal lighting, but upon the limits of tolerance required by public safety. These limits are outlined and discussed in Section V on Safety Limitations.

Below is a synopsis of the contents of the report:

I. INTRODUCTION—Instructions to the committee and plan of report; general outline of the headlighting problem.

II. THE REQUIREMENTS OF VISION—Road illumination; intensity, distribution, direction; visual sensitometric data; threshold, discrimination; glare; central spot, oblique, momentary and veiling glare; adaptation, ideal lighting and limits of tolerance.

III. THE OPTICAL PRINCIPLES OF HEADLIGHTING—Optical elements of lamp and beam; specification and calculation of beam illumination; the modified beam; brightness and glare; out-of-beam illumination.

IV. PRACTICAL HEADLIGHTING — Road conditions; curving and uneven roads, crossings, approaching vehicles and pedestrians, sign boards, road margins, foliage, street lights, dust, fog, rain and snow; dimming and tilting headlamps; special mirrors and caps; special front glasses.

V. SAFETY LIMITATIONS—Discretion of driver; the headlight beam; oblique reflected light; minimum illumination, minimum spread, colored lights.

References to several papers pertaining to this and related subjects are included in the report. This report will prove of particular interest to those who have been following the tests conducted jointly by the illuminating Engineering Society and the S. A. E., accounts of which have appeared in the April and May issues of THE JOURNAL.

NATIONAL WAR SAVINGS DAY

GERMAN airplanes recently bombed a large American hospital. Hovering at low altitudes, every effort was made to hit the main building, which was conspicuously marked with the Red Cross emblem. Doctors and nurses were obliged to remove our wounded boys to trenches previously dug for such emergencies.

President Wilson, while reviewing the Red Cross parade in New York, was greeted by a Canadian soldier, invalided home from the front, who had been taken into the Canadian Army despite the fact that he was 54 years old when the authorities learned that his son was one of those that German soldiers crucified on a barn door.

National War Savings Day, Friday, June 28, gives an opportunity to register in a practical way a vow that such fiendish things must end!

A new opportunity to serve comes as a result of thus designating a day on which all men and women and all children of sufficient years to appreciate the day's significance are called upon to pledge themselves to save to the utmost of their ability and to conserve all possible labor and materials for the Government, and to buy war savings stamps with their savings. Our part is to do everything possible to make this day stand out among the great days of this period of the war. The National War Savings Committee, in calling attention to the thrift campaign which it is directing, says:

"Could any one of us be asked to do less than this? Could any one of us do so little a thing to win a war for the world's freedom? Could any one of us put aside this plea for saving while all Europe is crying out in its agony to be released from the clutches of the monster that is befouling all it touches? Could we refuse so simple a thing and at the same time ask other men to give their lives that our own precious lives be spared and our firesides be kept safe from the terrors of the Hun?

"Our duty is clear, our privilege is great, our sacrifice is little, our work is important.

"What the Government asks us to do is to pledge ourselves to buy at definite periods with our savings a specific amount of war savings stamps. The thing to be accomplished is to get subscriptions which will take care during the balance of the present year of the unsold portion of the $2,000,000,000 of war savings stamps authorized by the Congress to be sold during 1918.

"The duty of us at home is to see to it that the entire amount is subscribed. We must work to that end. We must add to our already great army of war savers. We must make more sacrifices ourselves and urge sacrifices upon others."

Current Standardization Work

AT the meeting of the Standards Committee held in Dayton on June 16 at the time of the Semi-Annual Meeting of the Society, various divisions submitted reports making definite recommendations for standardization. These reports, as accepted for submission to mail vote, are now being prepared for printing in complete form, and therefore only an outline will be given here.

Aeronautic Division

The subjects taken up in the report of the Aeronautic Division are the serving wire for loops for non-flexible single-strand steel cable; diameter limits of aircraft screws and bolts; aircraft bolt-head and nut dimensions and bolt thread pitches; turnbuckles.

The various dimensions for turnbuckle and associate fittings, in the formulation of which representatives from the Army, Navy, aircraft manufacturers, and turnbuckle manufacturers participated, were approved by the Society last June in Washington. They were never sent out in data sheet form (for the S. A. E. Handbook) because it was desired to have the American and British types interchangeable, thus materially facilitating repairs at the front.

The British Air Board standard turnbuckle dimensions have since been received and compared with those proposed here. By widening the slot in the fork end of the S. A. E. 1600-lb. and 3200-lb. sizes from 0.109 to 0.150 in., thus permitting the use of the lower grade steels which are more easily obtained for strainer-clips, and by making two or three other minor modifications, the S. A. E. and British turnbuckles can be made practically interchangeable.

The Aeronautic Division has previously recommended pitches for bolt sizes No. 8 to $\frac{5}{8}$ inclusive. Exception has been taken to the 12-32 size, by both the Army and Navy, it being asserted that this should be 12-28 to correspond to the A. S. M. E. pitch. At the time the recommendation was made, the majority of aircraft manufacturers were using the 12-32 pitch, and in order not to interfere with production it was decided that it should be used as a war measure.

As both the Army and Navy have issued specifications calling for the 12-28 pitch, it was recommended that the 12-32 pitch be changed to 12-28 for all S. A. E. aircraft screws and bolts in order to unify American aircraft practice. It was also recommended that aircraft bolt sizes 4-48 and 6-40 be added to the list of S. A. E. aircraft screws and bolts.

It is believed that the basic formulas for determining bolt-head and nut dimensions should be recorded so that the system of progression of present standards will be more clearly understood, and, in event of extension, a basis of calculation will be available.

Ball and Roller Bearings Division

Annular Ball Bearings.—As an outcome of the conference of the Ball and Roller Bearing Section of the American Aircraft Commission with the British Engineering Standards Committee, held in London, in March, a cablegram was sent to the Society and referred to the Division requesting a modification and revision of tolerances for metric sizes of annular ball bearings. After considering the situation, the tolerances on S. A. E. annular (radial) ball bearings have been completely revised, the standard S. A. E. tolerances as to bore and outside diameter being materially reduced in line with the improvement of the art and in close agreement with the suggestions of the above-mentioned conference.

In connection with these changes the tables of annular ball bearings have been revised to correspond in form with the tables of thrust bearings already standardized.

When working to the fine tolerances given for annular ball bearings a slight change in temperature is sufficient to cause a change in the bearing dimensions, such that the actual measurements are outside the allowable limits. This would result in the rejection of bearings which, if measured under proper temperature conditions, would come within limits. Likewise, a change in temperature of gages might for the same reason result in the rejection of the bearings. It is necessary, therefore, that care be exercised to maintain both bearings and gages at a uniform standard temperature during inspection, and in so far as possible during manufacture. In order to establish uniform practice and to safeguard the inspection and manufacture of bearings and to prevent unnecessary rejections the Division recommended that the tolerances of annular ball bearings be applicable only when the bearings and measuring appliances have been brought to a uniform standard temperature.

Roller Bearings.—Metric Sizes. Information came to the Division through the Ordnance Department of the United States Army that it has had difficulty in interchanging straight roller bearings with certain taper roller bearings, owing to differences in fitting tolerances. Before action could be taken on this matter by the Division the Ordnance Department had straightened out its difficulties with the roller-bearing makers concerned, it is understood, by changing the S. A. E. tolerances so as to produce proper functioning of their bearings. When this matter was brought up at the Division meeting the question of revision of the present S. A. E. standards, with particular reference to tolerances, and the possibility of changing the title to be "Straight Roller Bearings," was also considered. This entire subject is in the hands of the Division for further action and consideration at an early date.

Thrust Bearing Tolerances.—At the same time that work was undertaken on the radial bearings similar work had been started on metric thrust bearings for aircraft and other heavy duty. While considerable data have been collected on this, and the table is in process of formulation, the matter has not yet progressed to so complete a solution as to warrant issuance at this time.

Data Sheet Division

Several definite recommendations for increasing the usefulness of the S. A. E. Handbook were submitted by the Data Sheet Division, the recommendations covering a new sheet numbering system, a classified sectional index, data sheet and data curve additions.

Electrical Equipment Division

The subjects covered in the report of the Electrical Equipment Division are the number of teeth and pitch

of starting motor pinions; location of the starting switch; the marking of electrical fuses; standardization of the shaft dimensions and methods of driving of ignition distributor mounting to make it interchangeable for both engine and generator mountings; pinion opening locations for flange mountings for starting motors; terminals for starting-motor cables. Other subjects mentioned in the report are new flange mountings for starting motors; sleeve type starting motor mounting and generator shaft-end for coupling drive.

Generator Bracket Mounting.—There is no standard for bracket-mounting of generators. Assemblies other than the standard flange mounting are not interchangeable for different sizes and makes of generators on different engines, which condition necessitates special assembling and needless manufacturing costs.

The generator manufacturers represented on the Division have signified their willingness to furnish bracket mountings for generators, which will fit a standard mounting pad on the engine, if the engine manufacturers will furnish such a pad.

The Engine Division therefore has been cooperating in this work of preparing an engine-pad recommendation for the Standards Committee.

Engine Division

Hand Starting Cranks.—At present there are many different attachment methods and shapes of hand starting cranks. If a shaft diameter and method of attachment for permanent and detachable cranks, and a definite crank offset are standardized practically all of the requirements will be met and an economic advance made. The Engine Division has made a recommendation with this end in view.

Magneto Drive-Shaft and Coupling Dimensions.—The nominal drive-shaft diameter and length and the distance from the drive-shaft to the magneto shaft-end for tractor engines have already been standardized by the Society. Recommendations have been made in order to complete the present standard. Other subjects in the report are thermostat connections; engine support arms; generator bracket-mounting pads, general dimensions for the latter being formulated in cooperation with the Engine Division.

Iron and Steel Division

The American Society for Testing Materials has submitted to the S. A. E. two specifications for Bessemer and open-hearth screw stock recommended for adoption at the June meeting of the A. S. T. M. A report covering this matter was submitted by the Iron and Steel Division.

Tire and Rim Division

The Tire and Rim Division submitted definite recommendations on the following subjects:

1. Pneumatic-Tire Sizes, Passenger Cars and Commercial Vehicles.
2. Rim Sections and Contours, Pneumatic Tires for Passenger Cars and Commercial Vehicles.
3. Valve Holes in Rims for Passenger Cars and Commercial Vehicles.
4. Valve Holes for Motorcycle Rims.
5. Carrying Capacities, Inflation Pressures for Automobile Pneumatic Tires.
6. Routine Test of Rims for Automobile Pneumatic Tires.
7. Wood Felloe Dimensions, Pneumatic-Tire Rims.
8. Wood Spoke Dimensions, Commercial Vehicle Wheels.

The report is concluded by a proposed specification relating to tires and rims for airplane landing wheels; at the present time this specification is not submitted for definite action.

Tractor Division

The Tractor Division has made recommendations of speed and widths for power belts and pulleys; a simplified series of bolts and screws; carbureter flanges; pipe marking; steels, and the use of certain existing S. A. E. standards.

Complete Specification Form.—Tractor manufacturers can make good use, it is believed, of a complete specification form for recording detailed technical data. (A Condensed Tractor Specification Form, already adopted by the Society, is intended mainly for general commercial requirements.) A complete form, proposed by the Division, will serve a purpose similar to that of the specification sheet included in the standard S. A. E. Engine Testing Forms.

REPORT OF THE MAY COUNCIL MEETING

THE May meeting of the Council was held at New York on the 20th, with the following present: President C. F. Kettering, Vice-President David Beecroft, Second Vice-Presidents Dent Parrett and H. R. Brate, Councillors B. B. Bachman, H. L. Horning, C. W. McKinley, J. V. Whitbeck, B. B. Whittelsey, and Secretary Coker F. Clarkson.

It was voted to make the following transfers in grade of membership: From Associate to Member grade: Walter Brown, Eugene C. Duval, Wm. McMahan, G. M. Rymarczick and Gustav Wade. From Junior to Member grade: Valentine C. Kloepper.

Applicants to the number of 57 were elected to membership in the Society, these being assigned to grades as follows: 23 members, 20 associate members, 9 junior members and 5 student enrollments.

The resignations of the following were accepted: Milford E. Bliss, Charles Boyden, Wm. C. Carter, S. A. Fletcher, Gordon Grimes, Ray P. Jackson, W. M. Gressley, Horace D. Haight, Edgar Menderson, Wm. F. Polson, Neil E. Salsich and H. L. Zabriskie.

The following changes in affiliate representatives were approved: Pyrene Mfg. Co., New York; substitution of E. J. Waring, vice-president for C. Louis Allen.

The Rowe Calk Co., Hartford, Conn.; substitution of Harold Wyman, factory manager, for R. H. Booth.

The Boeing Airplane Co., Seattle, Wash.; substitution of J. W. Miller, chief engineer, for J. C. Foley.

Standard Woven Fabric Co., Walpole, Mass.; dropping of Richard Everett.

Webster Electric Co., Racine, Wis.; addition of E. M. Ford.

It was voted to approve the application of John O'Neill for life membership in the Society.

The Council received a report made on behalf of the Publication Committee that work had been started in the preparation of Part I of the 1918 S. A. E. Transactions.

The following additions were made to the Standards Committee with assignments to Divisions as given below:

F. G. Diffin, Aeronautic Division.

David F. Chambers, Ball and Roller Bearings Division.

E. A. Johnston, Tractor Division.

Frank W. Davis, Truck Division.

H. L. Greene was designated to serve as chairman of the Iron and Steel Division, and Herbert Chase as chairman of the Nomenclature Division, the latter succeeding the late Frederick R. Hutton.

The June meeting of the Council was held on the 16th, at Dayton, just previous to the Semi-Annual Meeting of the Society.

CAPTAIN O. J. MAY

The death of Captain O. J. May occurred on May 16 at the Washington Sanitarium, Washington, D. C. Captain May entered the service in June, 1917, as a captain in the Engineers Reserve Corps, and was recommended as a captain in the Signal Corps in November, 1917, being assigned to the Lubrication Department, an entirely new department, the organization of which was entrusted to him. He had full charge of the experimental work necessary in the preparation of specifications covering lubricating oil for aeronautic engines. This work necessitated elaborate tests at the Washington Navy Yard, where he had full charge of a corps of Army and Navy engineers. Very important work, also under his charge, was carried on at the altitude testing laboratory at the Bureau of Standards, where, in the first consecutive tests made in this laboratory, he stood a watch of sixty-five hours without leaving the work, which to an extent indicated his remarkable physical endurance and the tremendous interest and conscientious responsibility he felt in the work.

Captain May had full charge of the lubrication engineers and oil-house men who were recently established in the various aviation fields in this country, and had charge of the special experimental testing work in connection with lubricants and fuel at Dayton and at various manufacturing plants.

Captain May was a man of action and results, and considered among the best lubrication engineers in the country. As an indication of the appreciation of his ability and service, he was recommended by the chief of the Lubrication Department early in February for promotion of the rank of major.

While on a tour of inspection in connection with his work recently he contracted a case of rheumatism, which subsequently attacked his heart and resulted in his death.

Captain May was born at Chicago May 15, 1878. His technical education consisted of a laboratory testing course at the Lewis Technical School. For five years he was engaged in steam engineering and for ten years in electrical engineering work. He installed the 50,000-hp. hydroelectric plant of the Chicago Sanitary District, located at Lockport, Ill. Prior to entering the Army he held the position of chief lubrication engineer of the Texas Company. Captain May was an associate member of the American Society of Mechanical Engineers, and on Dec. 14, 1916, was elected a Member of the Society of Automotive Engineers.

Honor Roll of Society Members

THE following members have recently entered the services of the government in civilian or military capacities. This list, together with the "Service Directory of Members" following, is intended to contain the names of all members connected with the government, either in the military service or in civilian capacities. The names are listed in two parts, the first showing the members who have actually entered the military services, and the second those engaged as civilians. Every effort is made to have the addresses correct. It is therefore requested, in case of any error, that the member concerned immediately inform the New York office of the Society, so that a proper correction can be made. Members who have actually entered the service in any capacity, and who are not listed, should also write the details to the New York office.

MILITARY HONOR ROLL

Bare, Erwin L., first lieutenant, Military Truck Production Section, Quartermaster Corps, U. S. N. A., 205 Union Station, Washington.

Barker, C., pilot cadet, Royal Flying Corps, Canada.

Bedford, E. A., U. S. A., A. E. F., France.

Benjamin, David, Co. A, Training Detachment, Valparaiso, Ind.

Bibb, John T., Jr., second lieutenant, reserve military aviator, Aviation Section, Signal R. C., Washington.

Bigelow, A. C., second lieutenant, Motor Transport Section, Quartermaster Corps, U. S. A., 205 Union Station, Washington.

Bleakley, P. A., sergeant, Ordnance Department, U. S. N. A., Camp Herring, Peoria, Ill.

Brinton, Bradford, major, Quartermaster Corps, U. S. A., Washiington.

Eggen, O. E., 337th Field Artillery, Ordnance Corps, U. S. A., Camp Dodge, Iowa.

Ehlers, Paul, Battery E, 304th Field Artillery, U. S. A., A. E. F., France.

Fredricksen, Arthur, first-class machinist's mate, Aviation Section, U. S. Navy, Camp Perry, Great Lakes, Ill.

Frevert, Carl B., first lieutenant, Ordnance R. C., A. E. F., France.

Friedgen, A. E., first lieutenant, Engineering Section, Motor Transport Service, Quartermaster Corps, Washington.

Guernsey, Charles, captain, Engineering Section, Motor Transport Service, Quartermaster Corps, U. S. N. A., Washington.

Heckel, C. E., second lieutenant, Motor Transport Division, Quartermaster Corps, Washington.

Hicks, Harlie H., captain, Aviation Section, Signal R. C., Washington.

Hobbs, J. W., first lieutenant, Ordnance R. C., U. S. A., commanding officer, Fourth Heavy Mobile Ordnance Repair Shop, Camp Hancock, Ga.

Kinkead, R. S., sergeant, Third Reserve Officers Training Corps, Field Artillery, Washington.

Landon, Charles H., second lieutenant, Aviation Section, Signal R. C., Camp Dick, Dallas, Tex.

Leopold, Joseph, second lieutenant, Aviation Section, Signal R. C., Massachusetts Institute of Technology, Cambridge, Mass.

MacDonald, K. B., lieutenant commander, U. S. N. R. F., Naval Aircraft Factory, League Island Navy Yard, Philadelphia.

Moffett, Paul R., captain, Aviation Section, Signal Corps, Washington.

Moore, Harold T., sergeant, Quartermaster Mobile Repair Shop No. 302, Co. 2, American Expeditionary Forces, via New York.

Morgan, M. B., major, Engineering Division, Motor Equipment Section, Ordnance Department, Washington.

Nichol, Alfred H., Biplane Engineering Department, Signal Corps, U. S. A., Dayton.

Ommundson, H. P., chief quartermaster, Aviation, U. S. Naval Air Station, Miami, Fla.

Oswalt, W. L., first lieutenant, Ordnance R. C., 304th Mobile Ordnance Repair Shop, Camp Meade, Md.

Parramore, T. H., Motor Transport Service, Quartermaster Corps, U. S. A., Washington.

Pettis, John G., chief machinist's mate, Aviation Section, U. S. N., Washington.

Pullen, Daniel D., lieutenant colonel, Tank Corps, Corps of Engineers, Headquarters A. E. F., France.

Romeyn, Radcliffe, Inspection Division, Ordnance Department, Washington.

Sewall, E. B., U. S. N. R. F., Washington.

Skinner, Harlan C., private, Ordnance Detachment, U. S. A., Edgewood Arsenal, Edgewood, Md.

Spence, Hans P., first lieutenant, Quartermaster Corps, U. S. A., Camp Custer, Mich.

Tyler, O. P., captain, Ordnance R. C., Headquarters 22nd Class Motor Instruction School, Rock Island, Ill.

Underhill, C. R., captain, radio officer, school for aerial observers, Aviation Section, Signal R. C., Langley Field, Hampton, Va.

Wadsworth, George R., major, chief engineer, Naval Aircraft Factory, Navy Yard, Philadelphia.

Yonkin, Harry F., first lieutenant, Ordnance R. C., care Chief Ordnance Officer, A. P. O. No. 717, A. E. F., France, via New York.

CIVILIAN HONOR ROLL

Cowan, Stuart, special work, Clothing and Equipment Division, Manufacturing Branch, Office of Quartermaster General, 109 East Sixteenth Street, New York.

Corlett, Robert C., student engineer of tests, U. S. Army Training School, Carnegie Institute of Technology, Pittsburgh.

Davis, Charles Ethan, consulting engineer, Ordnance Department, Washington.

Denkinger, George Marshall, Signal Corps, U. S. A., Washington, assigned to Aviation Section as aeronautical engineer.

Fryer, Roy C., chief instructor, starting, lighting and ignition division, War Educational Department, University of Cincinnati, Cincinnati.

Loudon, Warren P., expert cost accountant, Signal Corps, U. S. A., New York.

Perrin, J. G., aeronautical mechanical engineer, Production Engineering Department, Signal Service at Large, care Major Gray, Washington.

Rider, W. Keith, Production Engineering Department, Signal Corps, U. S. A., Dayton.

Woodworth, P. B., district educational director, War Department, Tribune Building, Chicago.

Service Directory of Members

Military Service

ALDEN, HERBERT W., lieutenant-colonel, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington.*

ALDRIN, EDWIN E., lieutenant, Coast Artillery Corps, U. S. A., *Ft. McKinley, Maine.*

ALTER, ARTHUR S., chief machinist's mate, U. S. N. R. F., *Washington.*

AMON, CARL H., first lieutenant, Aviation Section, Signal R. C., 1st Motor Mechanics' Regiment, A. E. F., *France.*

ANDERSON, OSCAR G., private, Co. A, 1st Prov. Ordnance Depot Battalion, U. S. A., (mail) P. O. No. 713, A. E. F.

ANDERSON, E. S., lieutenant, Aviation Section, Signal Corps, U. S. A., Rockwell Field, *San Diego, Cal.*

ANDERSON, WILLIAM C., lieutenant, Engineer R. C., *Brooklyn, N. Y.*

ARNOLD, BION J., lieutenant colonel, Aviation Section, Signal R. C., *Washington.*

BAKER, FRANCIS H., chief machinist's mate, U. S. N. R. F., U. S. Naval Gas Engine School, Columbia University, *New York.*

BARKER, C. NORMAN, pilot cadet, Royal Flying Corps, *Camp Borden, Can.*

BARNABY, R. S., ensign, U. S. N. R. F., *Buffalo,* assigned to inspection duty.

BARTON, W. E., first lieutenant, Quartermaster R. C., *Washington.*

BATES, WM. O., JR., first lieutenant, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington.*

BEVIN, SYDNEY B., captain, Engineering Bureau, Motor Equipment Section, Ordnance Department, U. S. R., *Washington.*

BIBB, JOHN T., JR., lieutenant, Aviation Section, S. R. C., Love Field, *Dallas, Texas.*

BILLINGS, C. M., first lieutenant, Ordnance Department, U. S. A., *Rock Island, Ill.*

BLAIR, C. A., corporal, 472d Aero Squadron, A. E. F., *France.*

BLANK, M. H., first lieutenant, Motor Equipment Division, Ordnance R. C., Grant Motor Car Co., *Cleveland.*

BLOOD, HOWARD E., captain, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio,* assigned as business executive, Airplane Engineering Department.

BOGGS, GEO. A., lieutenant, Quartermaster Corps, U. S. A.; (mail) Farmers Loan & Trust Co., *Paris, France.*

BOWEN, C. H., captain, Military Truck Production Section, Office of Quartermaster General, *Washington.*

BRANDMEIER, F. M., Signal Corps, U. S. A., Motor Transport School, Wilbur Wright Field, *Fairfield, Ohio.*

BRISCOE, FRANK, captain, Signal Corps, U. S. A., *France.*

BRITTEN, DANIEL L., captain, Ordnance R. C., *Washington,* assigned to Gun Division, Ordnance Section.

BRITTEN, WM. M., major, engineer of motor transportation, Quartermaster R. C., *Washington.*

BRODIE, JAMES S., Engineer Corps, U. S. N. A., *Washington.*

BROWN, HAROLD HASKELL, first lieutenant, Coast Artillery Corps, U. S. N. A., *Fort Totten, N. Y.*

BROWNE, ARTHUR B., captain, Sanitary Corps, U. S. N. A., (mail) General Motors Co., *Detroit.*

CALLAN, JOHN LANSING, lieutenant, Reserve Flying Corps, U. S. N., U. S. S. Seattle, (mail) Postmaster, *New York.*

CAMPBELL, ARCHIBALD F., Aviation Section, Signal R. C., *Washington.*

CAMPBELL, LINDSEY F., 4th Battery, 2d P. T. R., *Fort Sheridan, Ill.*

CHASE, A. M., major, Ordnance Department, U. S. A., *Washington.*

CLARK, EDWARD L., first lieutenant, Signal R. C., McCook Field, *Dayton, Ohio.*

CLARK, ELMER J., captain, Signal R. C., *Buffalo, N. Y.*

CLARK, VIRGINIUS E., lieutenant colonel, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

CLARKE, A. FIELDER, Ground School, Aviation Section, U. S. N., *Washington.*

CLEAVER, CHARLES F., captain, A. S. C., British War Department, London, Eng., assigned as inspector of mechanical transport, (mail) Peerless Motor Car Co., *Cleveland.*

COCKRILL, EMMET, first lieutenant, Ordnance R. C., Ford Motor Co., *Highland Park, Mich.,* assigned as production officer and mechanical engineer.

COE, EDW. M., first lieutenant, Quartermaster Corps, U. S. A., *Washington,* (mail) Mechanical Repair Shops No. 302, A. E. F., *France.*

COFFMAN, DON M., first lieutenant, Aviation Section, Signal R. C., Commercial Bldg., *Dayton, Ohio.*

COLLINS, KENNETH G., first lieutenant, Signal R. C., A. E. F., *Italy,* (mail) 8th Aviation Instruction Center.

COMSTOCK, HERBERT F., cadet, Aviation Section, Signal Corps, A. E. F., (mail) 16th Foreign Detachment, A. P. O. 725, via *New York.*

DAHLQUIST, CHAS. S., major, Quartermaster Department, U. S. N. A., *Washington,* assigned to Motors Division as supervisor of inspection on standardized military trucks.

DAYTON, WILLIAM E., private, 306th Regiment, Field Artillery, U. S. N. A., *Washington.*

DEEDS, EDWARD A., colonel, Equipment Division, Signal Corps, U. S. A., State, War and Navy Bldg., *Washington.*

DENISON, ARTHUR H., cadet, School of Military Aeronautics, Massachusetts Institute of Technology, *Cambridge, Mass.*

DE LORENZI, ERNEST A., officer, Mechanical Transport, War Department, *London, Eng.*

DE WITT, GEORGE W., ensign, U. S. N., *France,* (mail) U. S. S. Utowana, Postmaster, *New York.*

DIAMOND, JAMES E., captain, Ordnance R. C., assigned to Motor Instruction School, *Kenosha, Wis.*

DICKEY, HERBERT L., captain, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington.*

DIMOND, G. A., first lieutenant, Motor Section, Ordnance R. C., Ft. Herring, *Peoria, Ill.*

DONALDSON, FRANK A., captain, Carriage Division, Ordnance R. C., Sixth and B Sts., *Washington.*

DOST, CHARLES O., first lieutenant, Aviation Section, Signal Corps, U. S. A., Ellington Field, *Houston, Texas,* assigned to engineering department.

DU BOSE, GEO. W. P., major, American Ordnance Base Depot, A. E. F., *France.*

DUNCAN, A. C., first lieutenant, Balloon Co. No. 7, Signal Corps, Aviation Section, Signal R. C., (mail) A. E. F., *France.*

DUNTLEY, LLOYD B., first lieutenant, Ordnance R. C., *Washington,* assigned to Engineering Motor Equipment Section.

EARLE, LAWRENCE H., captain, Ordnance R. C., assigned as inspector of ordnance, Holt Mfg. Co., *Peoria, Ill.*

EELLS, PAUL W., lieutenant, 330th Field Artillery, Artillery R. C., Camp Custer, *Battle Creek, Mich.*

ENGESSER, BENJ. M., School of Military Aeronautics, Massachusetts Institute of Technology, *Cambridge, Mass.*

ENGLISH, G. H., JR., first lieutenant, Ordnance R. C., *Washington.*

EVANS, GORDON M., captain, Engineering Bureau, Motor Equipment Section, Ordnance Department, U. S. R., *Washington.*

FARRELL, MATTHEW, captain, Quartermaster R. C., *Washington.*

FINKENSTAEDT, EDWARD R., captain, Military Truck Production Section, Office of Quartermaster General, *Washington.*

FISHLEIGH, W. T., major, Sanitary Corps, U. S. N. A., *Washington,* assigned as automobile engineer.

FITZGERALD, GERALD, second lieutenant, Motor Truck Co. 348, Camp McArthur, *Texas.*

FLANIGAN, E. B., Officers' Reserve Training Camp, *Plattsburg, N. Y.*

FORRER, J. D., captain, Engineer R. C., *Washington.*

FOSS, CLARENCE M., captain, Ordnance R. C., Rock Island Arsenal, *Rock Island, Ill.,* assigned to Motor Section.

FOSTER, WILLIAM J., second lieutenant, Signal R. C., U. S. A., *Washington,* assigned to Engine Design Section, Airplane Engineering Department, Aviation Section.

FOX, RUDOLPH H., first lieutenant, Ordnance R. C., *Washington.*

FRANKLIN, G. KING, captain, Motor Section, Ordnance R. C., *Washington.*

FULTON, RICHARD WALLACE, 5th Cadet Squadron, Aviation Section, Signal Corps, U. S. A., *Houston, Texas.*

FURLOW, JAMES W., lieutenant colonel, Quartermaster Corps, U. S. A., *Washington,* assigned to Office of Quartermaster General.

GAEBELEIN, ARNO W., lieutenant, Ordnance R. C., *Washington,* assigned to Carriage Division.

GARDNER, LESTER D., captain, 117th Aero Squadron, Signal Corps, U. S. A., *Washington.*

GETSCHMAN, G. F., second lieutenant, Ordnance R. C., *Washington,* (mail) Office of Inspector of Ordnance, Maxwell Motor Co., Chalmers Plant, *Detroit.*

GEY, WILLIAM, 377th Truck Train, U. S. N. A., Camp Merritt, *Tenafly, N. J.*

GFRORER, A. H., first lieutenant, Ordnance R. C., assigned as production officer, Maxwell Motor Co., Chalmers Motor Car Co., *Detroit.*

GIBBS, S. E., U. S. School of Military Aeronautics, University of Illinois.

GILLIS, HARRY A., major, Ordnance R. C., *Washington.*

GLOVER, F. S., major, Ordnance R. C., *Washington.*

GORRELL, EDGAR S., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., *Washington,* (mail) Air Service, A. E. F., *France.*

GRAHAM, LOUIS, captain, 309th Engineers, Engineers R. C., *Camp Zachary Taylor, Ky.*

GRAY, B. D., major, chief of production engineering department, Equipment Division, Aviation Section, Signal Corps, U. S. A., *Washington.*

GRAY, SAMUEL W., first lieutenant, Aviation Section, Signal R. C., U. S. A., (mail) 4th Co., 2d Motor Mechanics Regiment, Air Service A. E. F., *France.*

GREEN, GEO. A., major, Tank Section, British E. F., *France.*

GUTHRIE, JAMES, major, Ordnance R. C., *Washington,* assigned to Carriage Division, Engineering Bureau.

HAESKE, F. C., lieutenant, U. S. A., Camp Sherman, *Chillicothe, Ohio.*

HALL, C. M., major, Aviation Section, Signal Corps, U. S. A., *Dayton, Ohio.*

HALL, ELBERT J., major, Engine Design Section, Engineering Division, Signal Corps, U. S. A., *Washington.*

HALL, RICHARD H., JR., first lieutenant, Quartermaster Corps, U. S. N. A., *Washington.*

HARMS, HENRY W., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., (mail) Base Section No. 3, *London, England.*

HARTMAN, A. A., private, U. S. N. A., Camp Devens, *Ayer, Mass.*

HAWKE, CLARENCE E., Aviation Section, Signal Corps, U. S. A., *Washington.*

HECOX, F. C., captain, Quartermaster Corps, U. S. A., *Washington,* assigned to Engineering Bureau, Motor Division, in charge of standardization of military motorcycles.

HEGEMAN, HARRY A., major, Quartermaster Corps, U. S. A., *Washington*, assigned to office of Officer in Charge of Transportation.

HENDERSON, S. W., first lieutenant, Ordnance R. C., *Washington*.

HOBBS, J. W., first lieutenant, Ordnance R. C., U. S. A., (mail) Holt Mfg. Co., *Peoria, Ill.*

HOFFMAN, ROSCOE C., captain, Carriage Division, Motor Equipment Section, Ordnance R. C., *Washington*.

HORINE, M. C., second lieutenant, Aviation Section, Signal R. C., *Washington*.

HORNER, LEONARD S., major, Equipment Division, Signal Corps, U. S. A., *Washington*.

HOWARD, WALTER S., first lieutenant, Military Truck Production Section, office of Quartermaster General, *Washington*.

HOUSTON, HAROLD S., 3d Officers' Training Camp, *Fort Monroe, Va.*

HOYT, F. R., lieutenant, Aviation Section, Signal R. C., A. E. F., *France*.

HUBBELL, LINDLEY D., lieutenant colonel, U. S. N. A., Ordnance Department, *Springfield, Mass.*, assigned as Officer in Charge, Hill Shops, Springfield Armory.

HULL, M. LAIR, private, Ordnance Department, U. S. A., *Washington*, assigned to Trench Warfare Unit, Requirement Section, Control Bureau.

JACO, E. L., captain, Engineer R. C., U. S. A., *Washington*, assigned to General Engineering Depots.

JEFFREY, MAX L., first lieutenant, Military Truck Production Section, Office of Quartermaster General, *Washington*.

JENKS, WESTON M., U. S. N. R. F., Massachusetts Institute of Technology, *Cambridge, Mass.*, assigned as instructor in naval aviation.

JENNINGS, J. J., first lieutenant, Engineer R. C., Office of Chief Engineer, A. E. F., P. O. 717.

JONES, R. E., lieutenant, U. S. N. R. F., Washington, (mail) U. S. S. New York, Postmaster, *New York City*.

JOY, HENRY B., lieutenant colonel, 4th Motor Mechanics Regiment, Signal Corps, U. S. A., *Camp Hancock, Ga.*

JUNK, FRED H., second lieutenant, Aviation Section, Signal R. C., U. S. A., (mail) Signal Corps Aviation School, Carlstrom Field, *Arcadia, Florida*.

KALB, LEWIS P., major, Quartermaster Corps, U. S. N. A., *Washington*.

KENDRICK, JOHN F., Signal Corps, A. E. F., *France*, assigned to Research Inspection Division.

KENNEDY, H. H., lieutenant, Ordnance Department, U. S. A., *Washington*, assigned as inspector of ordnance.

KLEMIN, ALEXANDER, sergeant, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio;* assigned to research, Airplane Engineering Department, Aviation Section.

KLINE, H. J., first lieutenant, Ordnance R. C., *Washington*, assigned to Anti-Aircraft Section, Carriage Division.

KLOCKAU, W. F., private, Co. N, 4th Battalion, 163rd Depot Brigade, *Camp Dodge, Iowa*.

KOHR, ROBERT F., second lieutenant, Engineers R. C., *Washington*.

KOTTNAUER, EDWIN H., first lieutenant, inspector of ordnance, Ordnance R. C., U. S. A., (mail) Paige-Detroit Motor Car Co., *Detroit*.

LANE, ABBOTT A., first lieutenant, Aviation Section, Signal R. C., *Detroit, Mich.*

LANZA, MANFRED, major, Quartermaster Corps, U. S. A., 303rd Motor Supply Train, Camp Dix, *Wrightstown, N. J.*

LARSEN, LESTER REGINALD, second lieutenant, 107th Engineer Train, U. S. A., A. E. F., *France*.

LAVERY, GEO. L., JR., first lieutenant, Ordnance R. C., *Washington*.

LAY, ARTHUR J., captain, Aviation Section, Signal R. C., *Washington*.

LE FEVRE, WM. G., lieutenant, Train, 77th Division, U. S. A., Camp Upton, *New York*.

LEVY, ALFRED K., 3rd Ordnance Corps, assigned to Motor Equipment Section, U. S. N. A., *Washington*.

LEWIS, CHARLES B., captain, Ordnance R. C., Camp Lewis, *American Lake, Wash*

LEWIS, HARRY R., JR., captain, Ordnance R. C., Springfield Armory, *Springfield, Mass.*

LIBBEY, E. B., captain, 102nd Ammunition Train, 27th Division, U. S. A., *Spartanburg, S. C.*

LIPSNER, B. B., captain, Record Section, Aviation Section, Signal R. C., *Washington*.

LOEB, S. ARTHUR, lieutenant, Signal R. C., U. S. A., (mail) General Motors Corp., Buick Division, *Flint, Mich.*

LUDOLPH, F. E., Aviation Section, Signal Corps, U. S. A., Kelly Field No. 1, *S. San Antonio, Tex.*

MCGILL, GEO. E., Equipment Division, Aviation Section, Signal Corps, U. S. A., Packard Motor Car Co., *Detroit*.

MCCORMICK, BRADLEY T., captain, Ordnance Department, U. S. A., *New York*.

MCINTYRE, H. C., captain, Ordnance R. C., *Washington*.

MCMURTRY, ALDEN L., captain, office of Surgeon General, Sanitary Corps, U. S. N. A., *Washington*.

MACKIE, MITCHELL, major, Quartermasters Corps, U. S. A., A. E. F., *France*, assigned to Motor Truck Transport Section.

MACCOULL, NEIL, JR., U. S. N. R., *Washington*.

MARMON, HOWARD, major, Airplane Engineering Division, Signal R. C., McCook Field, *Dayton, Ohio*.

MARSHALL, W. C., captain, Ordnance R. C., *Washington*.

MARTIN, KINGSLEY G., captain, Quartermaster R. C., *Camp Dodge, Iowa*.

MASON, GEO. R., lieutenant, A. E. F., *France*.

MATTHEWS, MEREDITH, sergeant of ordnance, 7th Mobile Ordnance Repair Shop, 7th Division, U. S. A., (mail) Camp McArthur, *Waco, Texas*.

MAY, HENRY, JR., first lieutenant, Quartermaster C., N. A., *Washington*, assigned as inspector of Type B engines.

MAY, O. J., captain, Aviation Section, Signal R. C., Camp Custer, *Battle Creek, Mich.*

MEDER, CHARLES, 2nd Regiment, Co. 10, Section 1, Aviation Section, U. S. Naval Training Station, *Charleston, S. C.*

MERGI, WILLIAM, Co. B, First Battalion, 153d Depot Brigade, Camp Dix, *Wrightstown, N. J.*

METCALF, GEORGE R., JR., captain, Ordnance Department, U. S. N. A., *Washington*.

MICHEL, C. A., The Naval Auxiliary, Reserve Officers' Training School, Steamer J. H. Sheadle, Detroit River Station.

MIDDLETON, RAY T., first lieutenant, Air Service, A. E. F., *Paris, France*.

MILLER, B. F., major, Quartermaster Corps, U. S. A., *Washington*.

MILLER, C. A., first lieutenant, head checker, Quartermaster Corps, U. S. N. A., *Washington*.

MILLER, DONALD G., first lieutenant, Ordnance R. C., U. S. A., (mail) Nash Motors Co., *Kenosha, Wis.*

MITCHELL, C. B., lieutenant, 4th Motor Mechanics' Regiment, *Camp Hancock, Ga.*

MOFFAT, ALEX. W., ensign, commanding U. S. S. "Tamarack" (S. P. 561), Naval Defense Reserve, Postmaster, Foreign Station, *New York*.

MONCRIEFF, V. I., captain, Aviation Section, Signal R. C., *Washington*.

MORGAN, M. B., captain, Ordnance R. C., *Washington*.

MORRISS, PERCY G. B., Naval Aviation Corps, U. S. Navy, *Washington*, (mail) Aviation Headquarters, Great Lakes Naval Station, *Great Lakes, Ill.*

MURPHY, JOSEPH G., Sanitary Corps, U. S. N. A., *Washington*.

MYERS, J. L., first lieutenant, Motor Equipment Section, Ordnance R. C., U. S. A., (mail) Allison Experimental Co., *Indianapolis*.

NAHIKIAN, S. M., lieutenant, Aviation School, Massachusetts Institute of Technology, *Cambridge, Mass.*

NORRIS, G. L., captain, Signal R. C., U. S. A., *Pittsburgh, Pa.*

O'BRIEN, WM. B., JR., cadet, School of Military Aeronautics, Barracks No. 1, *Champaign, Ill.*

OGREN, CARL F., chief machinist's mate, Ordnance Inspection Department, U. S. N. R. F., *Washington*.

OLDFIELD, LEE W., captain, Signal R. C., *Washington*, assigned as aeronautical engineer.

OLIPHANT, LAURENCE, ensign, U. S. N., *Washington*.

OMMUNDSON, H. P., Flying Corps, U. S. N., Aeronautic Station, *Pensacola, Fla.*

ONG, D. G., first lieutenant, Aviation Section, Signal Reserve Corps, U. S. A., *Dayton, Ohio*.

ORTON, EDWARD, JR., major, Quartermaster R. C., *Washington*, assigned to Motor Transport Branch, Engineering Section.

OSBORNE, ARTHUR D., second lieutenant, Ordnance R. C., U. S. A., *Washington*.

OTTO, HENRY S., lieutenant, Intelligence Section, A. E. F., *France*.

PAGE, VICTOR W., first lieutenant, Aviation Section, Signal R. C., *Mineola, N. Y.*

PAINE, C. L., captain, Ordnance R. C., U. S. A., Headquarters 7th Mobile Ordnance Repair Shop, Camp McArthur, *Waco, Texas*.

PARKER, RICHARD E., captain, Quartermaster R. C., *Washington*, assigned to Southern Department.

PEARMAIN, W. J., captain, Ordnance R. C., A. E. F., *France*.

PECHNICK, FRANK J., 31st Balloon Co., U. S. A., Post Field, *Ft. Sill, Okla.*

PETERSON, F. SOMERS, ensign, Naval Air Station, *San Diego, Cal.*

PFEIFFER, BEN. S., first lieutenant, Ordnance R. C., Rock Island Arsenal, *Rock Island, Ill.*, assigned to Motor Section.

PICKARD, LYNN W., chief machinist's mate, U. S. Naval Air Service, A. E. F., *France*.

PIERCE, HUGH M., captain, Signal R. C., Call Field, *Wichita Falls, Texas*, assigned as engineer officer, Aviation Section.

POST, EDWIN M., JR., lieutenant, U. S. Air Service, A. E. F., *France*.

POTTER, AUSTIN E., lieutenant, U. S. N. R. F., U. S. Naval Aviation Forces, *France*.

POWELL, W. B., captain, assigned as officer in charge of mechanical transport, Imperial Ministry of Munitions, *Quebec, Can.*, (mail) P. O. Box 194.

PRATT, JESSE T., first lieutenant, Aviation Section, Signal Corps, U. S. A., *Washington*.

PULLEN, DANIEL D., major, 7th Regiment, Engineer Corps, U. S. A., A. E. F., *France*.

PURCELL, BERNARD A., captain, Quartermaster R. C., 307th Supply Train, Camp Gordon, Ga., assigned as Commanding Officer.

RANNEY, A. ELLIOT, major, Air Division, Signal Corps, U. S. A., *Washington*.

RAWLEY, JOS., captain, Co. A, 310 Engineers, U. S. A., Camp Custer, *Battle Creek, Mich.*

RICHARDSON, F. E., private, Engineer R. C., U. S. A., *Washington*.

RIDDLE, E. C., cadet, Aviation Section, Gerstner Field, *Lake Charles, La.*

RIFKIN, G., sergeant, inspector, Military Truck Production Division, Quartermaster Corps, U. S. N. A., (mail) Covert Gear Works, *Lockport, N. Y.*

RITTER, E. R., first lieutenant, Ordnance R. C., U. S. A., *Washington*, assigned to Production Division, Carriage Section.

ROBINSON, H. A., ensign, N. R., U. S. N., *Keyport, N. J.*

ROSE, CHARLES B., major, chief of planes and engine inspection, Inspection Department, Signal Corps, U. S. A., *Washington.*

ROSENTHAL, WM. C., sergeant, Engineer O. T. C., *Camp Lee, Va.*

ROUNDS, EDWARD W., U. S. N. R., U. S. Naval Aviation Detachment, *Cambridge, Mass.*

RUMNEY, MASON P., captain, Production Division, Ordnance R. C., *Washington.*

RUSSELL, EUGENE F., major, Ordnance Department, U. S. A., *Washington.*

SANDT, A. R., sergeant, Ordnance Department, U. S. A., *Washington,* assigned to Motor Equipment Section, Engineering Bureau.

SCHOENFUSS, F. H., captain, Gun Division, Production Section, Ordnance R. C., *Washington.*

SCHOEPF, T. N., captain, Engineer R. C., *Washington.*

SCHUPP, ARTHUR A., second lieutenant, Aviation Section, Engineering Department, New York Equipment District, Signal Corps, U. S. A., *Washington.*

SCOTT, ALLISON F. H., captain, Signal Corps, U. S. A., Langley Field, *Hampton, Va.,* assigned to Aviation Section.

SELFRIDGE, S. W., first lieutenant, Ordnance R. C., *Washington.*

SHAFER, M. S., second lieutenant, Signal R. C., McCook Field, *Dayton, Ohio,* assigned to Airplane Eng. Div.

SLADE, ARTHUR J., captain, Aviation Section, Signal R. C., *Washington.*

SLOANE, JOHN E., first lieutenant, aeronautical engineer, Aviation Section, Signal Corps, U. S. A., *Washington.*

SMITH, EDSON H., ensign, U. S. N. R., (mail) American & British Mfg. Co., *Bridgeport, Conn.,* assigned as assistant naval inspector of Ordnance.

SMITH, FRANK E., major, Signal Corps, U. S. A., *Washington.*

SMITH, G. W., JR., lieutenant, U. S. N. R., Naval Aircraft Factory, U. S. Navy Yard, *Philadelphia.*

SMITH, MARK A., first lieutenant, Marine Corps, U. S. N., *Washington.*

SMITH, WESTCOTT T., second lieutenant, Engineering Department, Aviation Section, Signal R. C., U. S. A., Chaunte Field, *Rantoul, Ill.*

SPERRY, LAWRENCE B., ensign, U. S. N. R. F., *Massapequa, N. Y.*

SPRAGUE, G. A., Co. D, 310th Engineers, Camp Custer, *Battle Creek, Mich.*

STAHL, R., lieutenant, U. S. Navy Seaplane Division, U. S. N. R., *Washington.*

STALB, A. ROLSTAN, ensign, U. S. N. R. F., (mail) Office of Operations, Aviation, Navy Annex, *Washington.*

STEINAU, J. M., sergeant, sanitary Corps, U. S. N. A., *Washington.*

STEVENS, C. C., Motor Equipment Section, Ordnance Department, U. S. A., *Washington,* assigned as draftsman.

STRAHLMAN, OTTO E., first lieutenant, Aviation Section, Signal R. C., (mail) Mechanics Training School, Overland Bldg., *St. Paul, Minn.*

STRAUSS, M. FRANK, first lieutenant, 307th Mobile Ordnance Repair Shop, 82nd Division, U. S. A., *Camp Gordon, Ga.*

STREETER, ROBT. L., major, Ordnance Department, U. S. A., *Rock Island Arsenal, Ill.,* in charge of truck and tractor experimental work.

STREICHER, GEORGE A., lieutenant, 3rd Engineers' Training Regiment, *Camp Humphrey, Va.*

SWEET, GEO. P., first lieutenant, Signal Corps, U. S. A., *Washington,* assigned to Aviation Section.

SWEET, GEO. W., captain, Ordnance Department, U. S. A., *Washington,* assigned as inspector of ordnance, Studebaker Corp., *South Bend, Ind.*

SWINTON, D. R., first lieutenant, Quartermaster Corps, U. S. N. A., Mobile Repair Shop 302, A. P. O. 708, A. E. F., via New York.

TAYLOR, PAUL B., sergeant, Medical Corps, U. S. A., *Pontiac, Mich.*

TAYLOR, S. G., JR., first lieutenant, Ordnance R. C., *Washington,* assigned to Ordnance Department.

TEETOR, D. C., captain, Ordnance R. C., *Kenosha, Wis.,* assigned to Motor Section.

THOMPSON, H. E., first lieutenant, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington.*

THOMPSON, JOHN A., Ordnance Department, U. S. A., assigned to Engineering Bureau, Motor Equipment Section, Ford Bldg., *Washington.*

THOMSON, CLARKE, lieutenant, Signal R. C., *Washington.*

TITSCH, WALTER H., captain, Quartermaster Corps, U. S. N. A., A. E. F., *France.*

TOLMAN, EDGAR BRONSON, JR., first lieutenant, 311th Engineers, U. S. A., Camp Grant, *Rockford, Ill.*

TURNER, HARRY C., captain, Engineer R. C., A. E. F., *France.*

TWACHTMAN, QUENTIN, first lieutenant, Engine Design Section, Signal R. C., *Washington.*

TYLER, O. P., captain, Ordnance R. C., U. S. A., *Rock Island, Ill.*

UNDERHILL, C. R., captain, Radio Section, Signal R. C., *Washington.*

VAIL, E. L., lieutenant, Aviation Section, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio,* assigned as officer in charge of instruments and accessories.

VERITY, CALVIN W., captain, superintendent of forge shop, Ordnance R. C., Frankfort Arsenal, *Philadelphia.*

VINCENT, JESSE G., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., Miami Hotel, *Dayton, Ohio.*

VONACHEN, F. J., lieutenant, Ordnance Department, U. S. N. A., Rock Island Arsenal, *Rock Island, Ill.*

WALDON, SIDNEY D., colonel, Equipment Division, Signal Corps, U. S. A., *Washington.*

WALL, WILLIAM GUY, major, Ordnance Department, U. S. A., A. E. F., *France.*

WALTER, MAURICE, first lieutenant, Ordnance R. C., *Washington.*

WALTON, FRANK, acting sergeant, Quartermaster Corps, U. S. A., Quartermaster Repair Unit, (mail) *Washington, D. C.*

WALTON, HAROLD E., 84th Aero Squadron, Signal Corps., U. S. A., Kelly Field, *San Antonio, Texas.*

WATSON, C. ROY, lieutenant, Aviation Section, Signal R. C., U. S. A., *Washington.*

WEAVER, E. W., aeronautical engineer, Engineering Department, Naval Aircraft Factory, Navy Yard, *Philadelphia.*

WEEKS, PAUL, captain, Ordnance Department, U. S. A., *Washington.*

WEISS, ERWIN A., sergeant, Ordnance Department, U. S. A., *Washington,* assigned to Engineering Bureau, Motor Section.

WELSH, W. E., Signal Corps, Aviation Section, U. S. A., *Washington.*

WETHERELL, S. P. JR., major, Quartermaster R. C., Motor Transport Service, A. E. F., *France.*

WHITTENBERGER, OWEN M., first lieutenant, Ordnance R. C., *Washington,* assigned to Office of Chief of Ordnance.

WILSON, H. C., major, 58th U. S. Artillery, Coast Artillery Corps, *Ft. Schuyler, N. Y.*

WILSON, T. S., lieutenant colonel, Field Artillery, *Santa Fe, N. M.*

WODEHOUSE, B. A., sergeant, Co. A, 339th Infantry, *Camp Custer, Mich.*

WOLFF, RUDOLPH D., U. S. N. R. F. No. 5, Great Lakes, U. S. A., assigned as chief petty officer.

WOOD, C. G., first lieutenant, Quartermaster Corps, U. S. A., *Washington,* assigned to Motor Transport Section, Office of Quartermaster general.

WOOD, FRANK B., captain, technical expert, Air Division, Signal R. C., U. S. A., *Washington,* (mail) 3rd Motor Mechanics Regiment, Camp Greene, *Charlotte, N. C.*

WOOD, HAROLD F., lieutenant, Specification Section, Equipment Division, Signal R. C., *Washington.*

WOODS, S. H., captain, Military Truck Production Section, Office of Quartermaster General, *Washington.*

WORKMAN, LEE W., 670th Aero Squadron, Aviation Branch, *Morrison, Va.*

YONKIN, HARRY F., first lieutenant, Ordnance R. C., A. E. F., *France.*

CIVILIAN HONOR ROLL

ADAMS, PORTER H., Office of the Section Commander, First Naval District, *Rockford, Me.*

ADAMS, RALPH L., Quartermaster Corps, U. S. A., *Washington,* assigned to Engineering Section, Motors Division.

ADAMS, H. J., War Industries Board, *Washington.*

AGINS, HERMAN J., draftsman, Quartermaster Corps, U. S. A., *Washington,* assigned to Motor Transport Division.

ANDERSON, E. S., mechanical engineer, Aviation Section, Signal Corps, U. S. A., Rockwell Field, N. Island, *San Diego, Cal.*

ANDERSON, H. C., aeronautical mechanical engineer, Production Engineering Department, Equipment Division, Signal Corps, U. S. A., Lindsey Building, *Dayton, Ohio.*

BARE, ERWIN L., automobile body designer, Office of Quartermaster General, *Washington.*

BARNABY, RALPH S., airplane inspector, Naval Reserve Flying Corps, *Buffalo, N. Y.*

BARNHARDT, GEO. E., aeronautical mechanical engineer, Signal Corps., U. S. A., Wilbur Wright Field, *Dayton, Ohio,* (mail) Cottage B6, Unit No. 1, Signal Corps, Aviation School, *Fairfield, Ohio.*

BARTON, CHAS. E., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio,* assigned to Airplane Eng. Department.

BELLING, G. C. C., assistant inspector of engineering material, U. S. Navy, *Buffalo, N. Y.,* (mail) Curtiss Aeroplane & Motor Corp.

BLAKEMORE, THOMAS L., aeronautical engineer, Bureau of Construction & Repair, U. S. N., *Washington.*

BOOTH FRED C., draftsman, Motor Transport Division, Quartermaster Department, U. S. A., *Washington,* (mail) Room 205, Union Station.

BOURQUIN, J. F., supervisor of chassis assembly, Military Truck Production Section, Office of Quartermaster General, *Washington.*

BRADFIELD, E. S., Engineering Department, Naval Factory, *Philadelphia.*

BREWER, ROBERT W. A., inspector of mechanical transports, British Army, London, Eng., (mail) Holt Mfg. Co., *Stockton, Cal.*

BUBNA, RICHARD C., designer, Engineering Office, Motor Transport Division, Quartermaster Corps, U. S. A., (mail) Room 305, Union Station, *Washington.*

BURTON, W. DEAN, aeronautical mechanical engineer, Signal Corps, U. S. A., *Fort Omaha, Neb.*

CALDWELL, FRANK W., aeronautical engineer, Aviation Section, Signal Corps, U. S. A., (mail) McCook Field, *Dayton, Ohio.*

CHAPMAN, ROBERT H., U. S. N., Spartanburg, S. C., assigned to Aeronautical Division.

CHAUVEAU, ROGER, aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington.*

CHERRY, RALPH E., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio,* assigned to Airplane Engineering Department.

CLARK, ELMER J., Signal Corps, U. S. A., *Portland, Ore.,* assigned as district manager of inspection.

CLARKE, THOMAS A., Signal Corps, U. S. A., *Washington,* assigned to Aviation Section as production expert.

CLEAVER, B. J., Medical Corps, U. S. A., General Motors Truck Plant, *Pontiac, Mich.*

COFFIN, HOWARD E., chairman, Aircraft Board, *Washington.*

COSTELLO, JOHN V., aeronautical engineer, airplane engineering division, Signal Corps, *Dayton, Ohio.*

CREAGER, F. L., in charge of electrical equipment tests, engineering laboratory, Motor Transportation Section, Quartermaster Corps, U. S. N. A., (mail) Room 205, Union Station, *Washington.*

CROW, HAROLD I., School of Military Aeronautics, University of California, *Berkeley, Cal.*, assigned as instructor in aeronautic engines.

DEKLYN, JOHN H., technical assistant, National Advisory Committee on Aeronautics, *Washington.*

DICK, ROBERT I., motor truck expert, Ordnance Department, *Camp Dodge, Iowa.*

DIFFIN, F. G., chairman, International Aircraft Standards Board, *Washington.*

DRESSER, L. W., mechanical engineer, Motor Transportation Division, Engineering Section, Quartermaster Corps, U. S. A., (mail) Room 306, Union Station, *Washington.*

DUVAL, EUGENE C., Signal Corps, U. S. A., assigned to Airplane Engineering Department, Mutual Home Bldg., *Dayton, Ohio.*

EDGERTON, A. H., Signal Corps, U. S. A., 870 Woodward Ave., *Detroit*, assigned to Equipment Division as gage supervisor.

EDMONDSON, D. E., U. S. Signal Service at Large, *Washington*, assigned as inspector of airplanes and airplane engines, Ericsson Mfg. Co., *Buffalo.*

EISELE, WILLIAM S., draftsman, Aviation Section, Signal Corps, U. S. A., *Washington.*

ELLIOTT, E. M., chief dispatcher, Emergency Fleet Corp., *Washington.*

ERICSON, FRIEHOF G., representative of Canada, International Aircraft Standards Board, *Washington.*

FERRY, PHILLIPS B., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

FLOGAUS, H. A., designer and checker, Motor Transport Engineering Division, U. S. A., (mail) Office of Quartermaster General, 205 Union Station, *Washington.*

FOWLER, HARLAN D., aeronautical engineer, Production Engineering Division, Aviation Section, Signal Corps, *Washington.*

FREHSE, A. W., engineer, Quartermaster Corps, U. S. A., *Washington*, assigned to Engineering Section, Motor Transport Division.

FRENCH, H. J., senior inspector, Pittsburgh District, Aviation Section, Signal Corps, U. S. A., *Philadelphia*, assigned to Inspection Department.

FROESCH, CHARLES, aeronautical mechanical engineer, Engineering Department, New York Equipment District, Aviation Section, Signal Corps, (mail) Aeronautical Engines Corps, *Long Island City, N. Y.*

GIBSON, HUGO, automotive purchasing, British War Mission, *New York.*

GIRL, CHRISTIAN, director, Military Truck Production Section, Office of Quartermaster General, *Washington.*

GRIMES, C. P., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio*, assigned to airplane engineering department.

GORMAN, E. J. B., U. S. Flying Corps, N. R., U. S. N., *Dayton, Ohio*, assigned to inspection of airplane engines, Dayton-Wright Aeroplane Co.

GRIFFITH, LEIGH M., technical expert, National Advisory Committee for Aeronautics, 518 Munsey Bldg., *Washington.*

GUERNSEY, CHAS., chief draftsman, Quartermaster Corps, U. S. A., *Washington*, assigned to Engineering Section, Motors Division.

HALE, W. A., aeronautical mechanical engineer, Signal Corps, U. S. A., *Dayton, Ohio.*

HALLETT, GEO. E. A., aeronautical mechanical engineer, Aviation Section, Signal Corps, Arcade Bldg., *Washington.*

HARRIGAN, F. P., aeronautical engineer, Equipment Division, Airplane Engineering Department, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

HARRIGAN, F. P., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio*, assigned to Plane Design Section.

HART, FRANK S., designer, Engineering Section, Motor Transportation Division, Quartermaster Corps, U. S. A., *Washington.*

HECKEL, C. E., truck designer, Transport Division, Quartermaster Corps, U. S. A., *Washington.*

HICKS, H. A., aeronautical engineer, Equipment Section, Aviation Section, Signal Corps, U. S. A. (mail) Major E. J. Hall, Lindsey Building, *Dayton, Ohio.*

HICKS, HARLIE H., airplane engineering division, Signal Corps, U. S. A., *Dayton, Ohio.*

HOBBS, J. W., automobile expert, Ordnance Department, Rock Island Arsenal, *Rock Island, Ill.*

HOLDEN, F. M., airplane engineering division, Signal Corps, U. S. A., *Washington.*

HONIGMAN, JOS. K., instructor, U. S. School of Military Aeronautics, Princeton University, *Princeton, N. J.*

HORNING, H. L., chief, Automotive Products Section, War Industries Board, *Washington.*

HOWER, HENRY M., production manager, New London Naval Base, *New London, Conn.*

KING, CHARLES B., aeronautical engineer, Aviation Section, Signal Corps, *Washington.*

KINGSBURY, J. A., metallurgist, Aviation Section, Signal Corps, U. S. A., (mail) Trego Motors Corp., *New Haven, Conn.*

KISHLINE, FLOYD F., laboratory assistant, Quartermaster Corps, *Washington.*

KROEGER, F. C., Quartermaster Corps, U. S. A., *Washington*, assigned as engineer on electrical equipment.

KUEMPEL, REUBEN, U. S. N., Naval Air Station, *Pensacola, Fla.*, assigned to Bureau of Steam Engineering.

LADDON, I. M., aeronautical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

LANE, ABBOTT A., inspector, Aviation Section, Signal Corps, (mail) Room 52, 870 Woodward Avenue, *Detroit.*

LEAVELL, R. A., Federal Board for Vocational Education, Washington, assigned as associate professor of mechanical engineering in charge of automobile instruction, Camp Joseph E. Johnston, *Jacksonville, Fla.*

LEOPOLD, JOS., Engineers' School, U. S. School of Military Aeronautics, Ohio State University, *Columbus, Ohio.*

LINCOLN, C. W., aeronautical engineer, airplane engine department, Equipment Division, Signal Corps, U. S. A., *Washington.*

LONGLETZ, WESLEY, Signal Corps, U. S. A., assigned as inspector on airplane engines at The Nordyke & Marmon Co., *Indianapolis.*

MACPHERSON, JAMES W., inspector of airplanes and airplane engines, Signal Service at Large, Signal Service, U. S. A., *Washington.*

MACDONALD, K. B., consulting engineer, Naval Aircraft Factory, *League Island, Philadelphia.*

MCDONALD, E. G., aeronautical engineer, Airplane Engine Division, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

MCCAIN, GEO. L., Signal Corps, U. S. A., *Dayton, Ohio*, assigned to airplane engineering department, Engine Design Section.

MCMASTER, MARCENUS D., aeronautical engineer, Motor Transportation Department, Signal Corps, *Washington.*

MENNEN, F. E., Quartermaster Corps, U. S. A., *Washington*, assigned to Transportation Division.

MILLAR, THOMAS H., JR., Engineering Section, Motors Division, Quartermaster Corps, *Washington*, (mail) Office of Quartermaster General.

MILLER, C. S., automotive engineer, U. S. A., Washington; (mail) 1750 Elkin Ave., *New Albany, Ind.*

MOORHOUSE, A., Signal Corps, U. S. A., Lindsey Bldg., *Dayton, Ohio*, assigned as engineer in Airplane Eng. Dept.

MORGAN, G. W., supervisor of plant survey, Military Truck Production Section, Office of Quartermaster General, *Washington.*

NELSON, A. L., aeronautical engineer, Aeroplane Engineering Department, Aviation Section, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

NEUMANN, JOHN W., Planning Section, Machine Division, U. S. Navy Yard, *Philadelphia.*

O'MALLEY, JOHN M., aeronautical engineer, Aviation Section, Signal Corps, U. S. A., Rockwell Field, *San Diego, Cal.*

OTIS, J. HAWLEY, Ordnance Department, U. S. A., Camp Dodge, *Des Moines, Iowa.*

PARISH, W. F., Signal Corps, U. S. A., *Washington*, assigned to Specification Section, Equipment Division.

PARKER, VICTOR C., Signal Corps, U. S. A., *Washington*, assigned to Equipment Division.

PARRIS, JR., EDWARD L., senior inspector, Aviation Section, Signal Corps, (mail) Ericsson Mfg. Co., *Buffalo.*

PERRIN, J. G., aeronautical engineer, Production Engineering Department, Aviation Section, Signal Corps, U. S. A., *Buffalo, N. Y.*

POLLOCK, RAY C., Signal Corps, U. S. A., *Buffalo*, assigned as airplane engine inspector.

PROCTOR, C. D., Ordnance Department, U. S. A., Rock Island Arsenal, *Rock Island, Ill.*, assigned to Motor Section, Carriage Division.

RANDALL, J. M., assistant inspector of ordnance, Ordnance Department, U. S. A., (mail) Nash Motors Co., *Kenosha, Wis.*

RICE, HARVEY M., inspector, Signal Service at Large, Signal Corps, (mail) Willys-Overland Co., *Toledo, Ohio.*

RIDER, W. KEITH, Signal Corps, U. S. A., *Washington*, assigned to Production Engineering Department.

RIPPINGILLE, E. V., Aviation Section, Signal Corps, *Washington.*

ROBERTS, D. S., inspector of airplanes and airplane engines, Aviation Section, Signal Corps, U. S. A., (mail) Standard Aircraft Corp., *Elizabeth, N. J.*

ROBERTS, SAMUEL B., inspector of airplanes and airplane engines, Signal Service at Large, U. S. A., (mail) Sturtevant Aeroplane Co., *Jamaica Plain, Mass.*

ROGERS, JOHN M., aeronautical engineer, Bureau of Construction & Repair, Navy Department, *Washington.*

RUCKSTELL, G. E., Signal Corps, U. S. A., assigned as aeronautical mechanical engineer, *Detroit.*

RUSSELL, L. L., Engineering Office, Motors Division, U. S. A., (mail) Office of Quartermaster General, 305 Union Station, *Washington.*

RYMARCZICK, GUSTAV M., Signal Corps, U. S. A., (mail) Splitdorf Electrical Co., *Newark, N. J.*, assigned to Aviation Sect., as senior inspector, Signal Service at Large.

SALISBURY, EDWARD V., chief of motor transportation, American International Corp., Government Shipbuilding Yard, Hog Island, *Philadelphia.*

SCHAUM, OTTO W., Signal Corps, U. S. A., Lindsey Building, *Dayton, Ohio*, assigned as aeronautical mechanical engineer, Production Engineering Department.

SHAW, B. RUSSELL, Aviation Engineering Department, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

SCHELL, JOHN A., aeronautical mechanical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

SEABURY, W. M., Field Hospital, No. 337, Camp Custer, *Battle Creek, Mich.*

SEABURY, W. WARNER, Signal Corps, U. S. A., Bureau of Standards, *Washington*, assigned to testing of aviation instruments.

SEARLE, C. A., auto-parts inspector, U. S. A., *Washington.*

SELLERS, MATTHEW B., Naval Consulting Board, *New York.*

SERRELL, ERNEST, aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington.*

SHILLINGER, G. P., Ground Officers' Engineering School, Kelly Field No. 1, *San Antonio, Tex.*, assigned as instructor in ignition, starting and lighting.

SIMPSON, HOWARD W., Signal Corps, U. S. A., *Detroit*, assigned as inspector of aircraft engines, Inspection Section, *Equipment Division*, (mail) 870 Woodward Ave.

SOULIS, WILBUR T., mechanical engineer, United States Gas Defense Plant, *Long Island City, N. Y.*

SPRAGLE, R. L., inspector, Detroit district, Signal Corps, U. S. A., Garfield Building, *Detroit.*

STANTON, D. T., military instructor, U. S. Army School of Military Aeronautics, Cornell University, *Ithaca, N. Y.*

STOUT, WILLIAM B., technical adviser, International Aircraft Standards Board, *Washington.*

STUART, H. R., Signal Corps, U. S. A., Lindsey Building, *Dayton, Ohio*, assigned as aeronautical mechanical engineer, Production Engineering Department.

THIBAULT, F. J., aeronautical mechanical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

THOMAS, T. R., mechanical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

TONE, FRED I., inspector, Aviation Section, Signal Corps, *Washington.*

TRACY, PERCY WHEELER, supervisor of parts plants, Military Truck Production Section, Office of Quartermaster General, *Washington.*

UTZ, JOHN G., supervisor of inspection, Office of Military Truck Production Section, Office of Quartermaster General, *Washington.*

VAN LOON, HENRY M., 310th Engineers, Camp Custer, *Battle Creek, Mich.*

VOHRER, W. R., draftsman, Engineering Section, Motor Division, Quartermaster Corps, U. S. A., *Washington.*

WADE, GUSTAV, inspector, Aviation Section, Signal Corps, *Dayton, Ohio.*

WALDON, C. O., National Bureau of Standards, *Washington*, assigned as laboratory assistant, Military Research Gas Engines.

WALDRON, RUSSELL E., Signal Corps, U. S. A., Detroit, assigned to Equipment Division.

WALKER, KARL F., automotive engineer, Quartermaster Corps, U. S. A., *Washington*, assigned to Engineering Laboratory.

WALTER, JOHN M., mechanical draftsman, Bureau of Ordnance, Navy Department, *Washington.*

WARNER, EDWARD P., aeronautical engineer, Signal Service at Large, U. S. A., Mass. Institute of Technology, *Cambridge, Mass.*

WATERHOUSE, W. J., aeronautical engineer, Aviation Section, Signal Corps, (mail) Dayton-Wright Airplane Co., *Dayton, Ohio.*

WHINNE, WILBUR H., inspector, Quartermaster Corps, U. S. A., *Detroit.*

WILLIAMS, S. T., Naval Aircraft Factory, Navy Yard, *Philadelphia, Pa.*, assigned as aeronautical mechanical engineer in Engineering Department.

WINTER, E. A., War Department, Rock Island Arsenal, *Rock Island, Ill.*

WORTHEN, C. B., inspector, Aviation Section, Signal Corps, U. S. A., *Washington.*

YOUNGER, JOHN, Quartermaster Corps, U. S. A., *Washington*, assigned to Motor Transportation Engineering Office, as supervisor of engineering.

Applications *for* Membership

The applications for membership received between May 22 and June 17, 1918, are given below. The members of the Society are urged to send any pertinent information with regard to these names which the Council should have for consideration prior to their election. It is requested that such communications from members should be sent promptly.

AIKEN, CHARLES W., production manager, works manager, Mitchell Motors Co., *Racine, Wis.*

ANDERSON, EDWIN GALLIMORE, sales manager, American Bronze Corp., *Berwyn, Pa.*

ANSTED, FRANK B., president, Lexington Motor Co., *Connersville, Ind.*

ARTHUR, C. W., special factory representative, Mitchell Motors Co., *Racine, Wis.*

BARTON, G. K., manager of Detroit office, The Texas Co., *Chicago.*

BAUER, LOUIS E., district manager, Equipment Division, Signal Corps, U. S. A., *Dayton, Ohio.*

BEASLEY, W. F., supervision, Engineering Bureau, War Department Motor Equipment Section, *Washington.*

BECK, FRITZ, consulting engineer, purchasing agent, 90 West Street, *New York.*

BOEHME, ERNEST, chief inspector, Dayton Engineering Laboratories Co., *Dayton, Ohio.*

BONHAN, F. A., general manager parts and service division, Chevrolet Motor Co., *New York.*

BRADLEY, S. S., general manager, Manufacturers Aircraft Association, *New York.*

BREWSTER, CLYDE, salesman, Edward A. Cassidy Co., of New York, *Detroit.*

BROWN, WILLIAM G., assistant Branch Manager, Bosch Magneto Co., *Chicago.*

CAMPBELL, SUMNER E., chief chemist, Tide Water Oil Co., *Bayonne N. J.*

CAROLIN, NORBERT, first lieutenant, Aviation Section, Signal Corps, U. S. A., Langley Field, *Hampton, Va.*

CASSIDY, JOSEPH F., truck service salesman, Packard Motor Car Co., *Long Island City, N. Y.*

CERVENKA, JOHN A., captain, Quartermaster Corps, N. A., Camp Meigs, *Washington.*

CHANONHOUSE, FRED S., engineer, general superintendent, production manager, Sturtevant Aeroplane Co., *Boston.*

CHAPMAN, CHARLES F., editor, International Magazine Co., *New York.*

CHOWN, R. D., draftsman, The Glenn L. Martin Co., *Cleveland, Ohio.*

CHUCAN, JOHN, mechanical engineer, Goodwin Car & Mfg. Co., *Chicago.*

CLOSE, L. W., assistant engineer, Standard Parts Co., *Cleveland.*

COLE, F. A., factory and sales departments, Laminated Shim Co., Inc., *New York.*

COLE, R. A., draftsman, Haynes Wheel Co., *Jackson, Mich.*

CONGDON, C. H., ensign, U. S. N. R. F., Bureau of Construction & Repair, *Washington.*

CONGER, Roy U., vice-president, Erie Specialty Co., *New York.*

COOK, C. A., sales engineer, Detroit Accessories Corp., 2025 Gratiot Ave., *Detroit.*

COOK, EVERETT J., chief engineer, E. B. Hayes Machinery Corp., *Oshkosh, Wis.*

COOK, M., secretary, general manager, Service Motor Truck Co., *Wabash, Ind.*

CROWHURST, HERBERT WALTER, second lieutenant, Quartermaster Corps, U. S. N. A., 205 Union Station, *Washington.*

CULBERTSON, J. G., general manager, secretary, treasurer, *Wichita Falls, Tex.*

DICKSON, ELIAS LEGRAND, manager of sales and service, Anchor Auto & Truck Co., *Sumter, S. C.*

DODGE, H. B., assistant chief engineer, Four Wheel Drive Auto Co., *Clintonville, Wis.*

EAGLES, NELSON W., engineer, American Car and Foundry Co., *Detroit.*

ENYEART, HARRY, layout draftsman, Rutenber Motor Co., *Marion, Ind.*

ERLICHMAN, ROBERT I., manager parts department, Commercial Car Unit Co., *Philadelphia.*

FEDERAL RUBBER CO., *Cudahy, Wisconsin.* Representatives: Arthur A. Frank, general factory superintendent; Leon J. D. Healy chief chemist; John Scherner, mechanical engineer

FITZSIMMONS, J. T., acting research engineer, Dayton Engineering Co., *Dayton, Ohio.*

FLINT, B. P., production engineer, Yuba Manufacturing Co., *Marysville, Cal.*

FRANK, ARTHUR A., general superintendent, The Federal Rubber Co., *Cudahy, Wis.*

FULLER, C. T., inspector of drawings, Naval Aircraft Factory, Philadelphia Navy Yard, *Philadelphia.*

GEORGE, EDWIN S., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., Motor Transportation Dept., *Washington*, or Garfield Bldg., *Detroit.*

GODDARD, CONRAD G., assistant engineer, mechanical interpreter, U. S. Govt., in service in technical dept., *Paris, France.*

GOLDSBOROUGH, PAUL, first lieutenant, Aviation Section, Signal Corps, U. S. Army, McCook Field, *Dayton, Ohio.*

HAGGOTT, WILLIAM S., assistant cable sales manager, The Packard Electric Co., *Warren, Ohio.*

HARBECK, J. N., president, Duesenberg Motors Corp, *New York.*

HASTINGS, LIEUT. CLARENCE E., inspector, Mechanical Transport, Dept. of Militia and Defense, *Canada.*

HAYES, RALPH S., inspector of electrical equipment for Class "B" trucks, Motor Transport Service, Q. M. Corps, U. S. A., *Washington.*

HEALY, LEON J. D., chief chemist, Federal Rubber Co., *Cudahy, Wis.*

HILL, NESTOR FRANCIS, assistant service manager, Gramm-Bernstein Sales Corp., *New York.*

HOLLIS, O. A., president, general manager, Hollis Tractor Co., *Pittsburgh, Pa.*

HOYT, GEORGE W., chief engineer, The Oakes Co., *Indianapolis.*

HUGHES, EDWARD, sales engineer, Dayton Engineering Laboratories Co., *Dayton.*

HUMMELL, W. H., superintendent, Grant Motor Car Corp., *Cleveland.*

JACOBI, E. R., chief inspector, Mitchell Motors Co., Inc., *Racine, Wis.*

JARDINE, CHARLES, engineer, Simms Magneto Co., *East Orange, N. J.*

JOHNSON, IRA L., charge of mechanical laboratory, Minneapolis Steel & Machinery Co., *Minneapolis.*

KALMES, JOS. W., clerk and purchasing agent, Four Wheel Drive Auto Co., *Clintonville, Wis.*

KEAGY, GEORGE, production manager, Teetor-Hartley Motor Corp., *Hagerstown, Ind.*

KIRK, WILLIAM P., sales engineer, manager, The Pratt & Whitney Co., *Cincinnati, Ohio.*

KLEIM, ADOLPH, motorcycle draftsman, Motor Transportation Corps., Quartermaster Corps, Room 203, Union Depot, *Washington.*

KNOCKE, LOUIS T., testing engineer, Waukesha Motor Co., *Waukesha, Wis.*

KNOX, CARLOS C., assistant inspector of engineering material, U. S. N., Bureau of Steam Engineering, 366 Rockefeller Bldg., *Cleveland.*

KRALUND, J., factory manager, Doehler Die Casting Co., 190 Huntington St., *Brooklyn, N. Y.*

LARSON, A. C., superintendent, Dodge Tool Co., *Grinnell, Iowa.*

LARSON, ELMER E., JR., draftsman, Emerson Brantingham Co., *Minneapolis.*

LASELLE, GEORGE W., draftsman, Service Motor Truck Co., *Wabash, Ind.*

LAWTON, OTTO A., owner, manager, Franklin Motor Car Co., *Boston, Mass.;* president, Franklin Motor Car Co., *Portland, Maine;* treasurer, director, Bela Body Co., *Framingham, Mass.;* director, Back Bay National Bank, *Boston, Mass.;* director, H. H. Franklin Mfg. Co., *Syracuse, N. Y.*

LE CAIN, J. H., aviation engine instructor, Massachusetts Institute of Technology, *Cambridge, Mass.*

LEES, GEORGE C., works manager, North American Motors Co., *Pottstown, Pa.*

LEWIS, GEORGE W., engineer in charge, Clarke Thomson Research, *Philadelphia.*

LINN, JOSEPH C., works manager, Teetor-Hartley Motor Corp., *Hagerstown, Ind.*

MACFARLAND, A. F., metallurgist, U. S. A. Ball Bearing Mfg. Co., *Chicago.*

MADISON, RICHARD DURHAM, designing draftsman, Ordnance Dept., U. S. A., *Washington.*

MARTINEAU, FRANCIS LEIGH, consulting engineer, 15 Avonmore Road, *London, W 14, Eng.*

MEREDITH, ROY B., assistant manager, Killen-Strait Mfg. Co., *Appleton, Wis.*

MORRISON, JAMES, vice-president, treasurer, factory manager, The Highland Body Mfg. Co., *Cincinnati, Ohio.*

MURRAY, JOHN W., president, John W. Murray Mfg. Co., *Detroit.*

NASH, FRED S., experimental engineering, Dayton-Wright Airplane Co., *Dayton, Ohio.*

NEWBOLD, GEORGE, business manager, Gardner Moffat Co., Inc., *New York.*

NEWTON, LEONARD V., supervisor of equipment, The Texas Co., *Chicago.*

OBER, SHATSWELL, aeronautical draftsman, Airplane Engineering Division, Aviation Section, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

O'DONNELL, L. A., treasurer, Gary Motor Truck Co., *Gary, Ind.*

OLSON, WM. O., general manager, charge of experimental work, Arc O Mfg. Co., *Chicago.*

PARKER, WORTHINGTON F., sales manager, The Packard Electric Co., *Warren, Ohio.*

PENDERSON, HOTHER, mechanical draftsman, The Four Wheel Drive Auto Co., *Clintonville, Wis.*

PHELPS, CHARLES C., publication department, Society of Automotive Engineers, *New York.*

PLATE, ROBERT T., detailer, draftsman, Grant Motor Co., *Cleveland, Ohio.*

PRICE, WM. T., president, Price-Engine Corp., *Philadelphia.*

RAND, LARS, engineer, Ordnance Department, Engineering Bureau, Tractor Unit, *Washington.*

RATHBUN, EDGAR A., treasurer, factory manager, American Forging & Socket Co., *Pontiac, Mich.*

ROBBINS, WALTER CLARK, engineer, Curtiss Aeroplane Motor Corp., *Buffalo.*

ROBERTSON, ROBERT B., sales manager, The Sturtevant-Jones Co., *Toledo, Ohio.*

RISCH, CHARLES H., sales engineering assistant, Pfanstiehl Co., Inc., 2 Columbus Circle, *New York.*

ROBISON, HENRY L., engine layout, tool designer, Rutenber Motor Co., *Marion, Ind.*

ROOF, R. M., chief engineer, Laurel Motors Corp., *Anderson, Ind. Chicago.*

RYDSTEDT, S. D., designer, Stewart Warner Speedometer Corp.,

SCHERNER, JOHN, mechanical engineer, Federal Rubber Co., *Cudahy, Wis.*

SCHLENDORF, J. M., director of sales, The Central Steel Co., *Massillon, Ohio.*

SCHRAFF, C. R., traffic director, Chevrolet Motor Co., *New York.*

SCHULZE, WM. H., assistant chief engineer, Stewart Warner Speedometer Corp., *Chicago.*

SCHULTZ, ERNEST EVANS, special representative, Hispano-Suiza, *Barcelona, Spain.*

SCOTT, PHILIP L., engineer in charge, engine department, Super Diesel Tractor Co., *New York.*

SCOTT, RAYMOND W., president, manager, Western Truck Attachment Co., *Seattle, Wash.*

SEARS, F. B., treasurer, Auburn Automobile Co., *Auburn, Ind.*

SELDEN, LIEUT. LYNDE, military aide of Commission to London Standards Conference, Aircraft Board, *Washington.*

SPRINGER, JOHN, chief engineer, Dickinson Cord Tire Corp., *New York.*

STALEY, EARL B., superintendent, Frank Waterhouse & Company, *Seattle, Wash.*

STENGER, EDWIN P., metallurgist, Sheldon Axle & Spring Co., *Wilkesbarre, Pa.*

STURT, FREDERICK B., specification work, Chevrolet Motor Co., *New York.*

SWAIN, JOSEPH G., vice-president, manager, The Firestone Steel Products Co., *Akron, Ohio.*

THOMAS, G. W., draftsman, Service Motor Truck Co., *Wabash, Ind.*

THOMAS, JOHN W., general superintendent, The Firestone Tire & Rubber Co., *Akron, Ohio.*

TOMLINSON, EDWARD J., experimental engineer, Splitdorf Electrical Co., *Newark, N. J.*

TUTTLE, JOHN C., manager of development department, Firestone Tire & Rubber Co., *Akron, Ohio.*

VAN DAM, LORING, ensign, U. S. N. R. F., Section "Q," Experimental Department, Bureau of Ordnance, Navy Department, *Washington.*

VAN PELT, H. B., vice-president, manager of sales, Pittsburgh Shafting Co. of Detroit, *Detroit.*

VAN SICKLEN, N. H., president, general manager, The Van Sicklen Co., *Elgin, Ill.*

VONANCHEN, FRANK J., second lieutenant, Ordnance Department, U. S. Army, Rock Island Arsenal, *Rock Island, Ill.*

WAERNER, T. A., sales engineer, Tidewater Oil Co., *New York.*

WAISNER, HORACE L., metallurgist, Mechanics Machine Co., *Rockford, Ill.*

WANNER, HARRY C., secretary, treasurer, Hammond Malleable Iron Co., *Hammond, Ind.*

WARD, H. A., advisory engineer, British Government, Royal Naval Air Service, Naval Aircraft Factory, *Philadelphia.*

WEHRLI, ERNEST H., designer, Militor Corporation, Bergen and Kearney Aves., *Jersey City, N. J.*

WELLER, G. W., assistant sales manager, Indiana Truck Corp., *Marion, Ind.*

WELLS, DAVID H., assistant production manager, L. W. F. Engineering Co., *College Point, N. Y.*

WELLS, M. R., assistant engineer, Peerless Motor Co., *Cleveland.*

WHITE, JOSEPH L., outside tester, Robert S. Taylor, *Seattle, Wash.*

WHITE, THOMAS HOLDEN, first lieutenant, Aviation Section, Signal Reserve Corps, Langley Field, *Hampton, Va.*

WIGGINS, E. R., technical editor, Chilton Co., *Philadelphia.*

WILDHACK, GEORGE O., proprietor, manager, The Wildhack Co., *Indianapolis, Ind.*

WOTTON, ED., superintendent of equipment, Fifth Avenue Coach Co., *New York.*

ZUEGE, H. W., production manager, L. W. F. Engineering Co. Inc., *College Point, N. Y.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between May 14 and June 17, 1918. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (S. E.) Student Enrollment.

ADAM, ROBERT M. (M) assistant chief draftsman, Edw. G. Budd Mfg. Co., *Philadelphia.*

ADAMS, FLOYD W. (A) purchasing agent,, Buick Division, General Motors Corp., *Flint, Mich.,* (mail) 1309 Grand Traverse St.

ALLEN, G. EDGAR (A) vice-president, general manager, Layman Connecting Rod Corp., 25 Broad St., *New York.*

ARNOLD, DOUGLAS L. (M) chief engineer of laboratories, gas power engineering department, International Harvester Corp., *Chicago,* (mail) 5526 W. Monroe St.

AYERS, BURLEY B. (A) advertising manager, American Steel & Wire Co., *Chicago,* (mail) 208 La Salle St.

BARNES, WM. B. (S E.) student, Purdue University, *Lafayette, Ind.,* (mail) c/o Barnes & Burnette, Helena, Ark.

BEDFORD, E. A. (J) chief engineer, United Motors Co., *Grand Rapids, Mich.*

BIGELOW, A. C. (J) 2nd lieutenant, Motor Transport Section, Quartermaster Corps, N. A., 205 Union Station, *Washington.*

BOONE, CHARLES H. (J) chief draftsman, Clark Equipment Co., *Buchanan, Mich.,* (mail) Box 402.

BRETAUD, JOSEPH V. (M) general superintendent, chief engineer, Swedish Crucible Steel Co., *Detroit,* (mail) 2936 W. Grand Boulevard.

BRINTON, BRADFORD (M) major, Quartermaster Reserve Corps, Washington; vice-president, Grand Detour Plow Co., *Dixon, Ill.,* (mail) *Dixon, Ill.*

BROWN, CHAS. S. (M) mechanical engineer, 726 W. Onondaga St., *Syracuse, N. Y.*

BUTZMAN, LESTER E. (J) chief draftsman. The Weger Aeronautical Motor Co., *Cleveland,* (mail) 9406 Columbia Ave.

CASS, LEE L. (M) designing engineer, Parrett Tractor Co., *Chicago Heights, Ill.,* (mail) 1527 Schilling Ave.

CASSEL, ADAM F. (A) material chaser, Chevrolet Motor Co., 1754 Broadway, *New York,* (mail) 52 W. 130th St.

CITROEN, ANDRE (M) engineer, head of firm, Andre Citroen Factory, 143 quai de Javel, *Paris, France.*

CORLETT, ROBERT C. (S.E.) student engineer of tests, U. S. Army Training School, Carnegie Institute of Technology, *Pittsburgh,* (mail) 619 N. East Ave., *Oak Park, Ill.*

CROCKER, ELMER S. (M) chief draftsman, The Militor Corp., *Jersey City, N. J.,* (mail) 2961 Boulevard.

CURRIE, CARLETON H. (S. E.) student, Michigan Agricultural College, *Lansing, Mich.,* (mail) 936 DeGroff St., *Grand Ledge, Mich.*

DAVIS, GORDON C. (J) tool design checker, Nordyke & Marmon Co., *Indianapolis,* (mail) 29 W. 1st St., *Dayton, Ohio.*

DUFFY, J. FRANK (M) assistant general manager in charge of production, Sumter Electrical Works, Splitdorf Electrical Co., *Sumter, S. C.*

EDWARDS, JAMES A. (A) aeronautical engineer, Hall-Scott Motor Car Co., *San Francisco, Cal.,* (mail) 1124 Carlton St., *Berkeley, Cal.*

EHLERS, PAUL (J) Battery E, 304th Field Artillery, A. E. F., *France.*

ELLISON, VICTOR R. (J) draftsman, Hall-Scott Motor Car Co., *Berkeley, Cal.,* (mail) 2214 13th Ave., *Oakland, Cal.*

EVANS, RICHARD W. C. (A) sales engineer, Ingersoll Milling Machine Co., *Rockford, Ill.,* (mail) 308 N. Church St.

FORD, E. M. (Aff. Rep.) sales manager, Webster Electric Co., *Racine, Wis.*

FRANKLIN, C. B. (M) assistant mechanical engineer, Hendee Mfg. Co., *Springfield, Mass.*

FULMER, CHAS. ALLEN (A) sales engineer, corner Burkhart and Garland Aves., *Dayton, Ohio.*

HACH, EDWARD C. (S. E.) draftsman, Chief Motor Co., *Port Huron, Mich.,* (mail) Y. M. C. A., *Port Huron, Mich.*

HEATH, CHAUNCEY B. (A) factory manager, secretary, Bantam Ball Bearing Co., *Bantam, Conn.*

HOBBS, CARL E. (A) proprietor, Hobbs Electric Repair Shop, 426-8 S. 4th St., *Springfield, Ill.*

HUNT, L. G. (M) engineer, Moline Plow Co., Tractor Branch, *Moline, Ill.* (mail) 635 41st St., *Rock Island, Ill.*

KERRUISH, EDWARD P. (M) in charge of drafting room, The Winton Co., *Cleveland.*

KOLBE, ADELBERT E. (J) layout draftsman, Jordan Motor Car Co., *Cleveland,* (mail) 1503 E. 75th Place.

KRAUSE, ALBERT H. (J) draftsman, Motor Transport Engineering Division, Quartermaster Corps, 306 Union Station, *Washington,* (mail) 162 Spring St., *New Haven, Conn.*

LAMBERT, H. E. (J) designer, Pan Motor Co., *St. Cloud, Minn.,* (mail) 1007 5th Ave. S.

LANDON, CHARLES HOWARD (J) 2nd lieutenant, Aviation Section, Signal Reserve Corps, *Camp Dick, Dallas, Tex.,* (mail) 174 Fargo Ave., *Buffalo, N. Y.*

LUZIUS, WILLIAM CHAS. (M) auto spring engineering, The Standard Parts Co., *Cleveland,* (mail) 3146 W. 73rd St.

MARTIN, L. J. (M) executive engineer, B. B. & C. I. Ry. Co., Inc., *Bombay, India,* (mail) Abu Road, *Rajputana, India.*

MARTIN, W. W. (A) senior member of partnership, The Martin-Whitehill Co., *Pittsburgh.*

MCKEE, L. Z. (A) sales manager, Oklahoma Auto Mfg. Co., *Muskogee, Okla.*

MILLER, J. W. (Aff. Rep.) chief engineer, Boeing Airplane Co., *Seattle, Wash.*

MORSE, E. R. (M) engineer, designer of chain drivers, Morse Chain Co., Morse Thermo Gage Co., Inc.; general manager, Thomas-Morse Aircraft Co., *Ithaca, N. Y.,* (mail) 111 Eddy St.

NIELSON, L. (M) chief engineer, Power Garden Cultivator Co., 932 McKnight Bldg., *Minneapolis,* (mail) 2549 Fillmore St., N. W.

ODEN, ERMUN D. (S. E.) student, International Correspondence School, *Scranton, Pa.,* (mail) 1504 Euclid Ave., *Marion, Ind.*

OSWALT, WALTER L. (A) 1st lieutenant, Ordnance Reserve Corps, 304th Mobile Ordnance Repair Shop, *Camp Meade, Md.*

PALMER, PAUL J. (A) aeronautical engineer, draftsman, Standard Aircraft Corp., *Elizabeth, N. J.,* (mail) 547 W. 123rd St., *New York.*

PARRAMORE, T. H. (M) Motor Transport Service, Quartermaster Corps, U. S. A., 7th and B Sts., *Washington.*

PEIRCE, CLARENCE A. (M) chief engineer, Diamond T Motor Co., *Chicago.*

PRYTZ, BJORN (A) president, S. K. F. Administrative Co., Inc., 5 Nassau St., *New York.*

ROGGE, LOUIS H. (M) vice-president, treasurer, The Dayton Wire Wheel Co., *Dayton, Ohio.*

ROSE, LOUIS H. (M) superintendent of heat treating, The Holt Mfg. Co., *Peoria, Ill.*

SCHWEDTMAN, F. C. (M) vice-president, The National City Bank of New York, 55 Wall St., *New York.*

SIMPSON, E. GLENN (M) chief engineer, airplane division, Fisher Body Corp., *Detroit,* (mail) 206 McLean Ave.

SPENCE, HANS P. (J) 1st lieutenant, Quartermaster Corps, N. A., *Camp Custer, Mich.*

STEENSON, JAMES H. (J) engineer, Standard Aircraft Corp., *Elizabeth, N. J.,* (mail) 230 Clinton Ave., *Plainfield, N. J.*

STEPHENS, E. E. (A) co-partner, The Double Seal Ring Co., *Kansas City, Mo.*

SUESZ, FERD J. (M) chief engineer, production manager, The Sayers & Scovill Co., *Cincinnati.*

TARBOX, GURDON L. (M) engineer, Standard Aero Corp., *Elizabeth, N. J.,* (mail) 30 De Hart Place.

TATE, CHAUNCEY G. (M) head of engine instruction department, Purdue University, *Lafayette, Ind.,* (mail) 241 Littleton St.

TAYLOR, KENNETH A., student, Armour Institute of Technology, *Chicago,* (mail) 619 Gary Place.

TINKLER, LOYAL G. (J) chemical engineer, *Little Falls, N. Y.*

UMBENHAUER, HARRY C. (A) secretary, treasurer, The Falls Tire Co. of Chicago, *Chicago.*

VANCE, A. H. (S. E.) experimental department, Lawrence Lewis Aeroplane Co., *Chicago,* (mail) 4200 Oakenwald Ave.

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Book Reviews *for* S.A.E. Members

This section of the S. A. E. JOURNAL is devoted to the technical books considered to be of interest to members of the Society. Such books will be described briefly as soon as possible after their receipt, the purpose being to show concisely the general nature of their contents and to give an estimate of their value.

INTERNATIONAL AIRCRAFT STANDARDS. Published by the Government Printing Office, Washington. Copies of the following may be obtained by application to the International Aircraft Standards Board, Washington:

Specifications for Airplane Spar Varnish. Published March, 1918.

Specifications for Unmercerized Cotton Airplane Fabric (Grade A). Published April, 1918.

Specifications for Mercerized Cotton Airplane Fabric (Grade B). Published April, 1918.

Specifications for Mercerized Cotton Airplane Fabric (Grade B). Published April, 1918.

AIRCRAFT MECHANICS HANDBOOK. By Fred H. Colvin. Published 1918 by McGraw-Hill Book Company, Inc., 239 W. 39th Street, New York City. Half-leather, 5 by 7 in., 400 pages, 200 ill. Price $3.

Mr. Colvin's compilation of facts and suggestions for caring for the modern airplane is most timely. Much valuable information, which to date has been available only in fragmentary form, has been incorporated in the volume. The material for the book was obtained, in the main, direct from factories and the flying field. The author claims no originality for the handbook, but believes that it represents the best practice known at this time. Its many suggestions will be of value to the experienced as well as the embryo airplane mechanic.

The contents are: The general construction; theory of planes; the propeller; wiring the plane; airplane standards of the S. A. E.; woods for airplane construction; airplane engines; the Curtiss engine; care and operation of Hall-Scott engines; the Sturtevant engine; the Thomas-Morse engine; Gnome engine; the Hispano-Suiza engine; U. S. Standard aviation or "Liberty" engine; characteristics of American airplane engines; notes and instructions to Government inspectors of airplanes and airplane engines; specification for U. S. A. military training (advanced) airplanes; details of training planes; assembling Curtiss training machines; general dimensons of training machines; how the "eyes" of the army work; the Canadian training camp at Borden; instruments for airplanes; the Lewis machine gun; tables and diagrams; terms used in aeronautics.

THE GASOLINE AUTOMOBILE, ITS DESIGN AND CONSTRUCTION. Fifth Edition of Vol. 1. By T. M. Heldt (M. S. A. E.) Published 1918 by the author at Nyack, New York. Cloth, 5¼ by 8½ in., 636 pages, illustrated with numerous line drawings and photographic reproductions. Price $5.

The previous edition of Vol. I of this work was printed on book paper not suited for the reproduction of halftone engravings. As a result many of the illustrations were of little value. The new edition is printed on a grade of paper much better suited to photographic reproduction, and the paper used is of additional advantage in lessening the bulk of the book in spite of the fact that it contains many more pages than the previous edition. Vol. I of Mr. Heldt's book is devoted entirely to the subject of the gasoline engine, whereas Vol. II covers the subjects of transmission, running gear and control. The new edition of Vol. I is now uniform as to size and style with Vol. II, the second edition of which was published last year. The author has not found it necessary to make any important changes in the text for the present edition in view of the fact that the previous one appeared a little more than a year ago. Formerly the plates were bound separately. In the new edition they have been incorporated in the book itself. The large size drawings as used previously have been reduced in size and it is believed that the more compact size will be of greater usefulness than the less handy folded sheets.

The author states that although only automobile and truck engines are dealt with directly, engineers in the aircraft, tractor, marine and motorcycle fields also have found the book useful in their work.

BIRDFLIGHT AS THE BASIS OF AVIATION. By Otto Lilienthal, translated from the Second Edition by A. W. Isenthal. Published 1911 by Longmans, Green & Company, Fourth Avenue and Thirtieth Street, New York City. Cloth, 6½ by 9½ in., 142 pages, containing portrait of the author, 94 line and photographic illustrations and 8 lithographic plates. Price $3.

This book was compiled from the results of numerous experiments made by Otto and Gustav Lilienthal and the present translated edition contains a biographical introduction and addendum by Gustav Lilienthal.

In their native German town of Anklam, these two brothers, as children, were interested in the flight of birds and butterflies, and had their imagination fired by books on flight and on nature study pertaining to birds. They became thoroughly convinced of the practicability of human flight and throughout their lives made a great many experiments, starting with simple models and eventually constructing elaborate winged machines. Evidently the brothers were convinced of the necessity of imitating the bird wing structure as nearly as possible, in fact feathers were used at first in the construction of the wing surfaces of their machines. Eventually Otto lost his life in an experiment with a glider.

The preface of the book states that up to nearly thirty years ago, when Otto Lilienthal first published a systematic account of his researches in the field of bird flight, the most varied and frequently impossible speculations were rife as to the causes which enabled birds to fly. Differences in specific gravity, special construction of the skeleton, anatomical special properties and the like, were invented to account for the ability of birds to sustain and alter their position in the air and in some cases even the fiat went forth that man should not attempt a feat which nature had evidently denied to him, and that he should not tempt Providence. Lilienthal, by applying his mechanical training to the problem of bird flight and by a series of systematic investigations, is credited with evolving some order from chaos and finally reducing the great mystery to a purely mechanical or dynamical basis, which although incomplete in many respects formed a nucleus from which future workers could proceed after rectifying some of the earlier assumptions which necessarily had to be made.

The scope of the work is best indicated by the subjects covered in the various sections, as follows: Fundamental principle of free flight; the art of flight and dynamics; force which lifts the bird in flight; air resistance; wings considered as levers; energy required for wing motion; actual path of wings and sensible wing velocity; apparent effort of birds; over-estimation of the

(Concluded on page 50, advertising section)

THE

JOURNAL
OF THE SOCIETY OF
AUTOMOTIVE ENGINEERS

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VOL. II JUNE, 1918 No. 6

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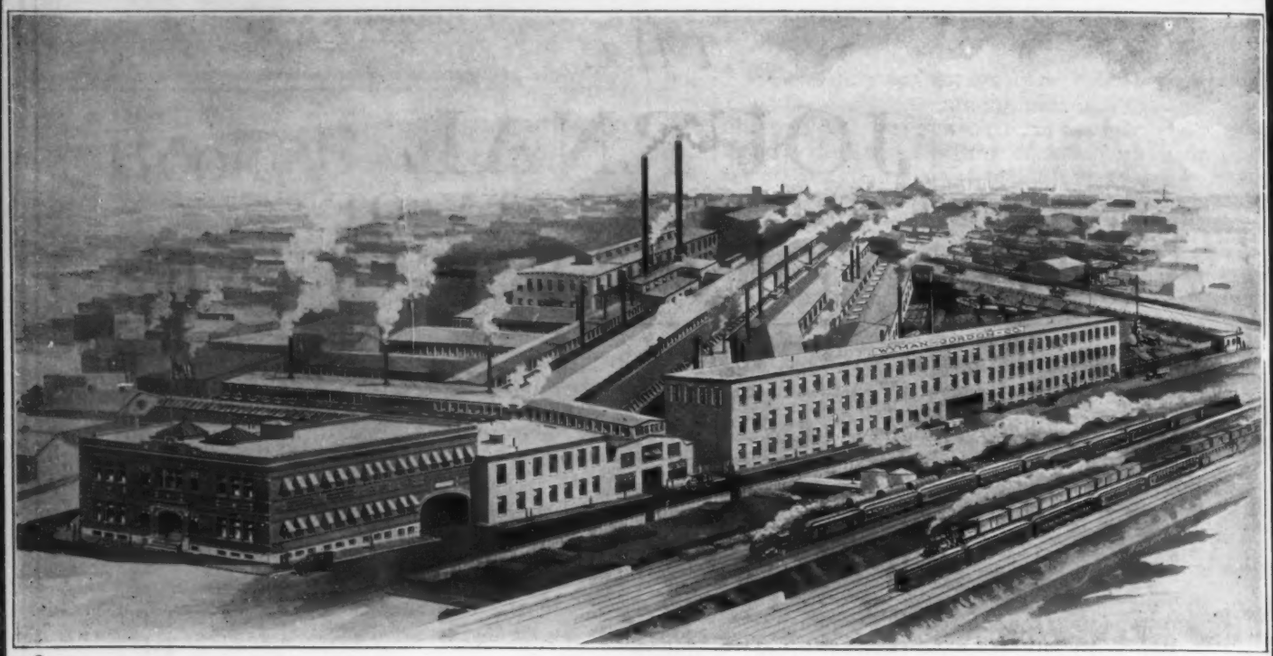
Announcement

The "Personal Notes of the Members," usually published each month, have been omitted in this issue on account of the extremely large number of changes in addresses and company connections which have been received for use in the 1918 Membership List. This List is now well under way and any members desiring it should so notify the Society office.



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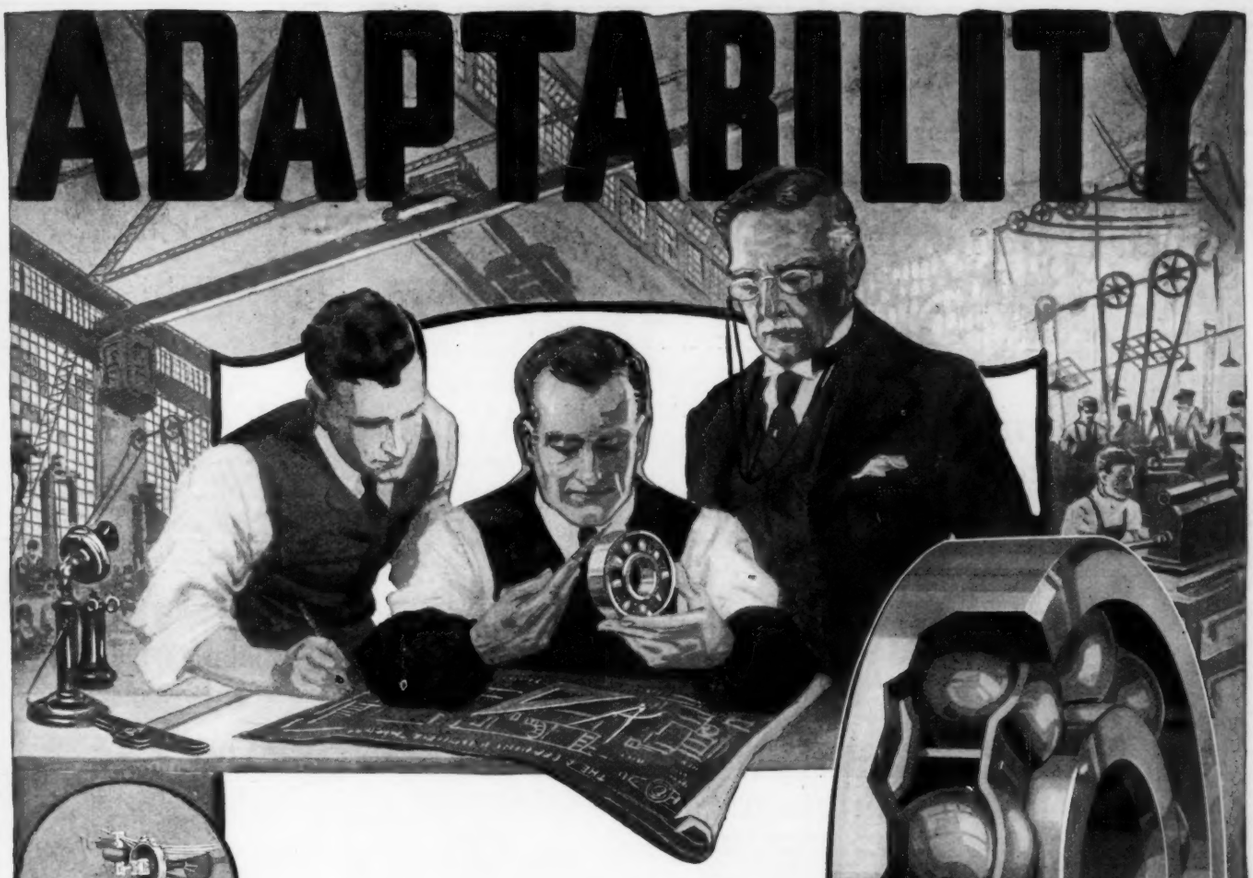

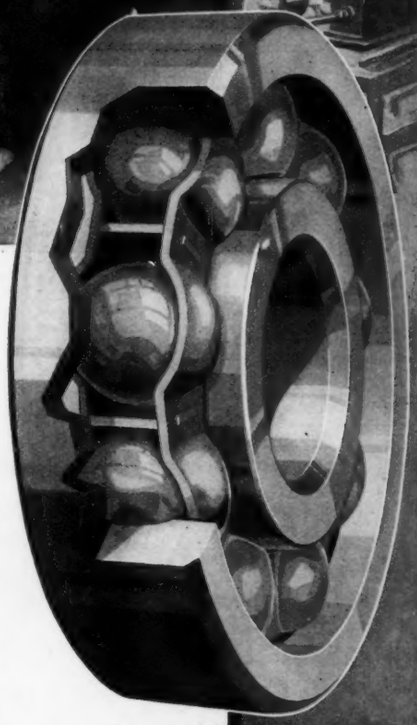

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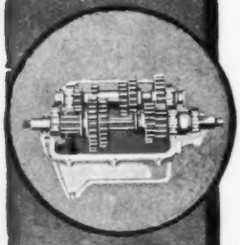

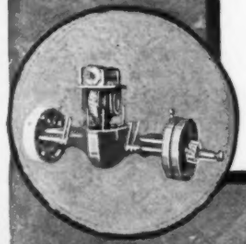

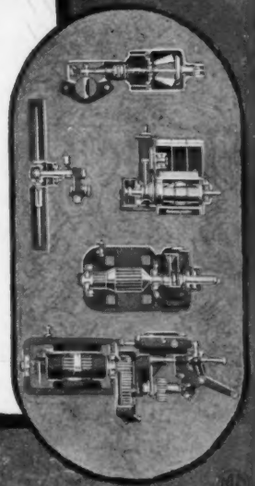

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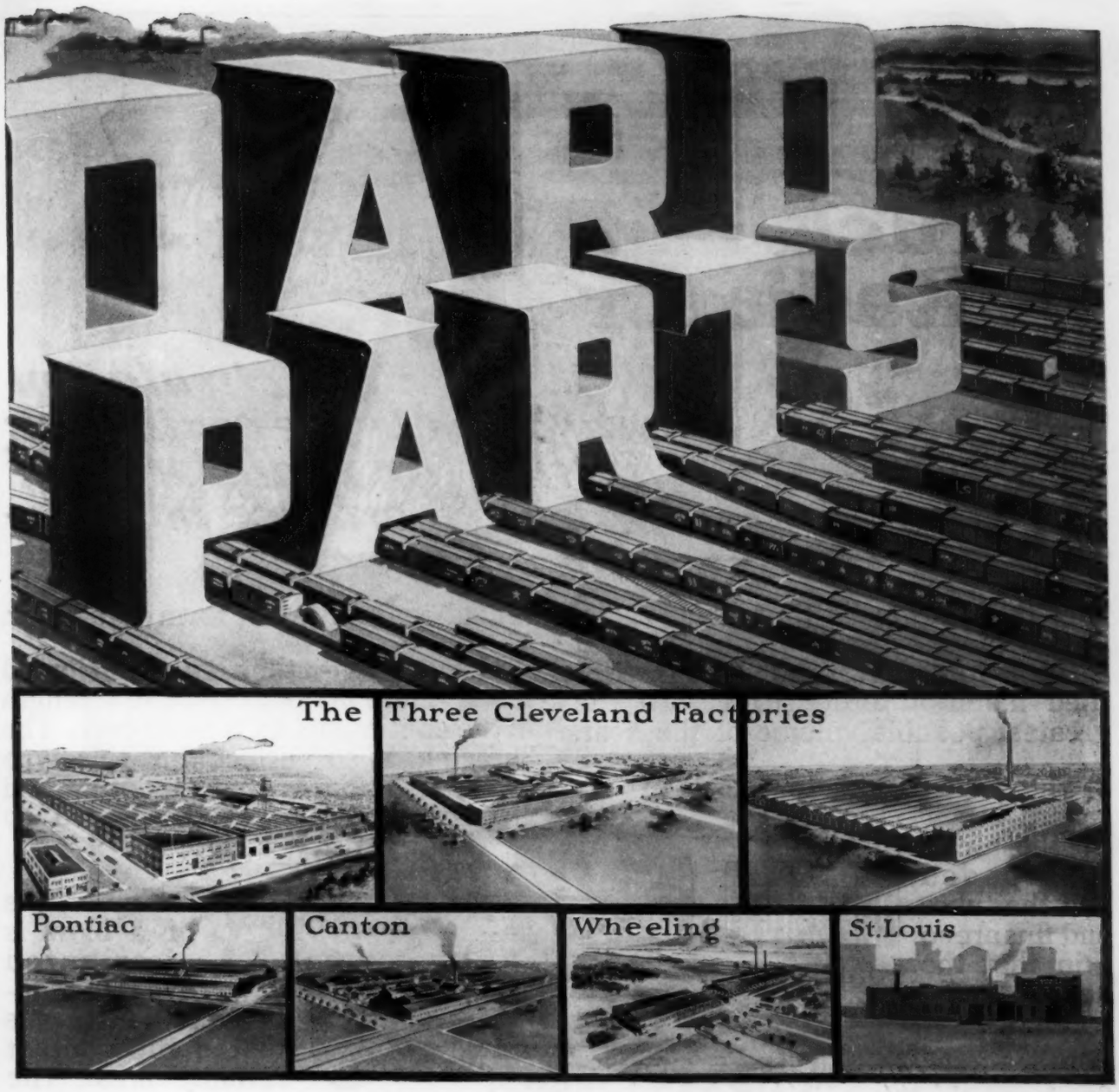

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Torsion Tubes
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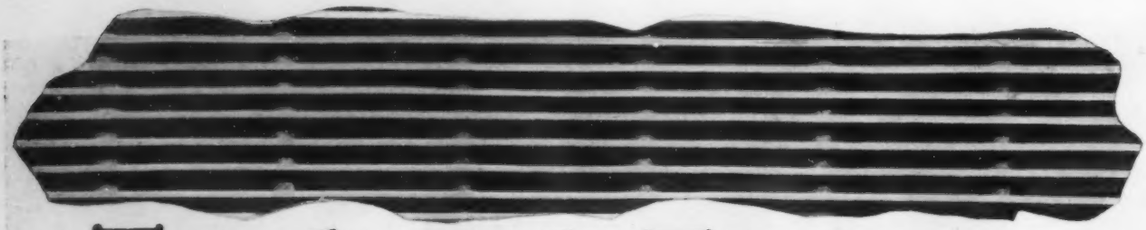

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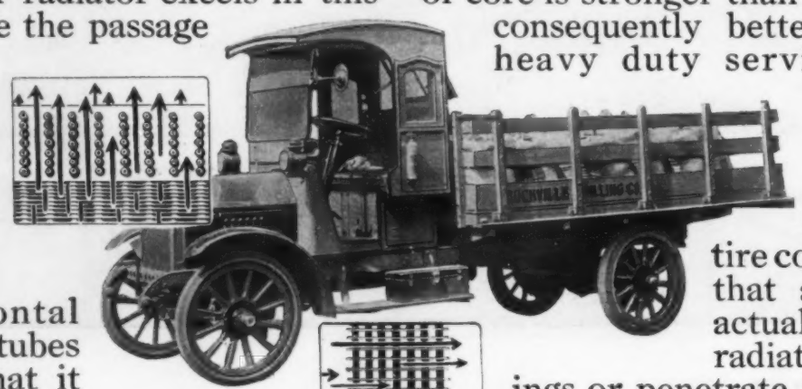
This type of radiator excels in this regard because the passage of the air is unimpeded and the tubes and fins are so thin that the heat is easily taken off.



The horizontal fins brace the tubes so securely that it is possible to use lighter tubes and fins than in other tubular types without sacrificing strength. Every part does its full share of the cooling since the distribution of the metal is uniform over every cubic inch of the core.

This means that greater efficiency is secured from every ounce of metal used than in any other form of radiator.

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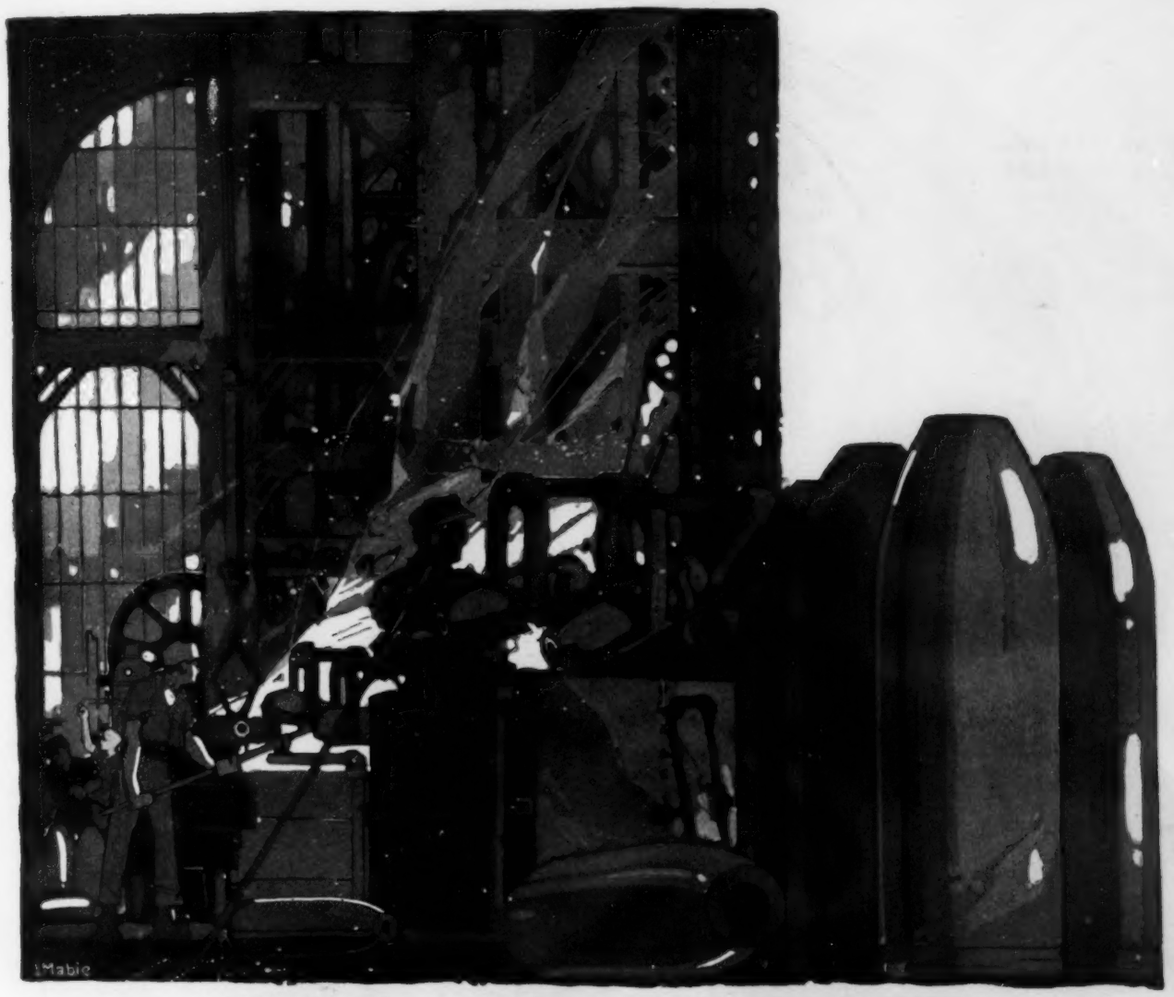

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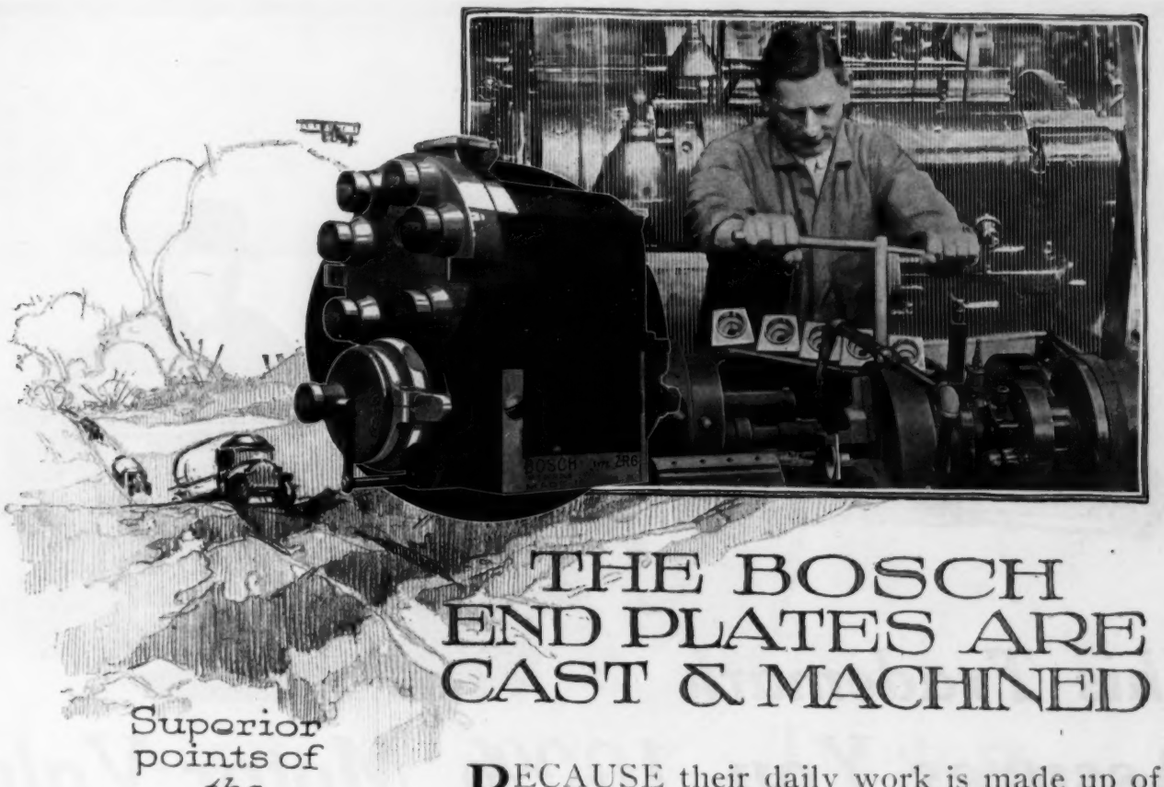

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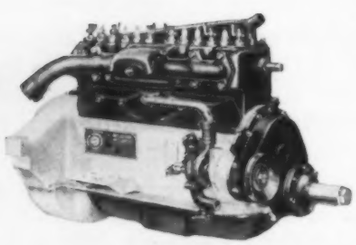

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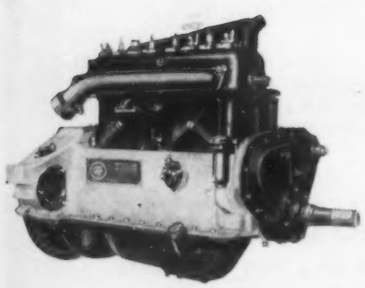

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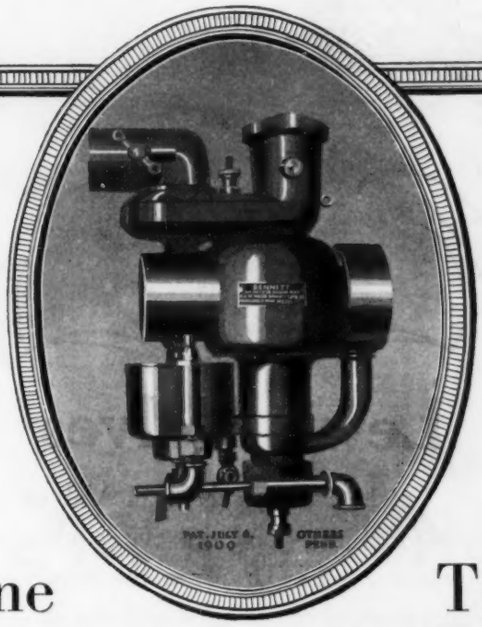

Kerosene Tractors Require Kerosene Carburetors

A tractor manufacturer added a kerosene device to his gasoline tractor and called it a kerosene tractor. After his service man drove it a few miles, something went wrong. He found that so much raw kerosene had worked past the pistons that the lubricating oil had become diluted and two bearings had burned out before he knew it.

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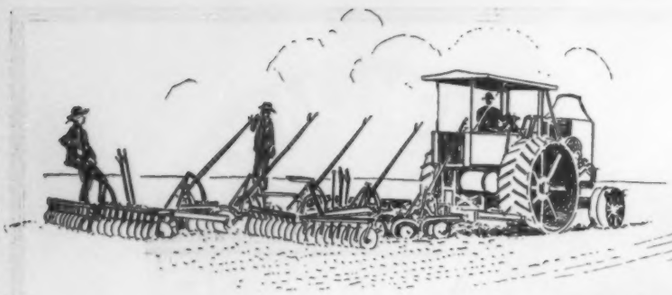
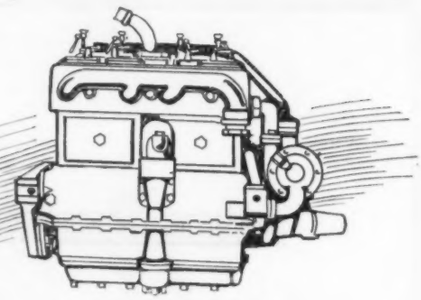
WILCOX-BENNETT CARBURETOR CO.
Specialists in Kerosene Carburetors
Minneapolis

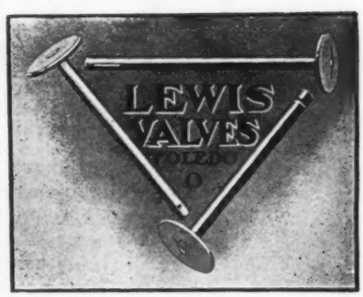
Bennett KEROSENE CARBURETOR





Lewis Valves

Lewis Semi-Steel Head Valves are making good in every case where tried. They are the result of practical experience and the development of careful research. They are true, trusty and reliable.



The

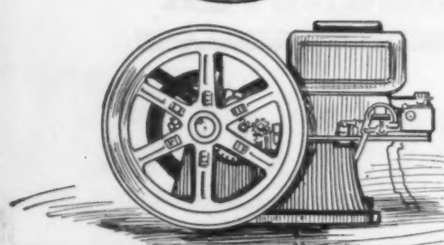
Lewis Steel Products Co.

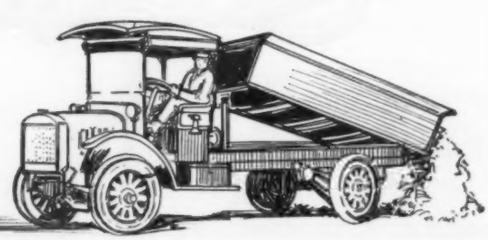
4080 Detroit Ave., Toledo, Ohio

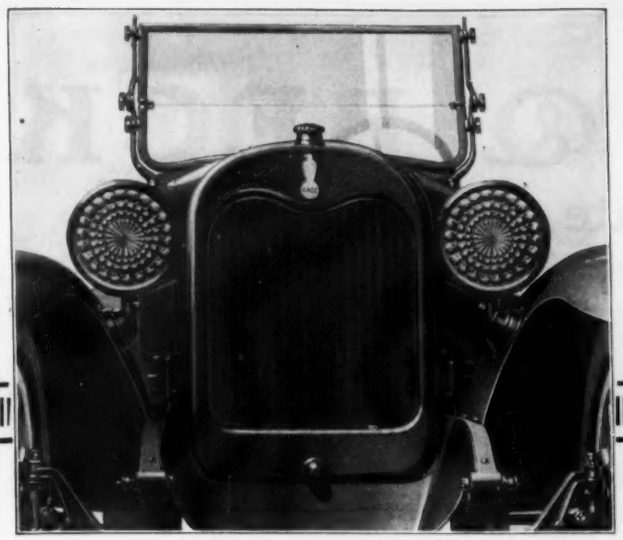
Successors to

THE LEWIS ELECTRIC WELDING & MFG. CO.

TOLEDO, OHIO







CASE

Among the 23 fine cars on which Warner-Lenz is Standard equipment

In Choosing Lenses Consider More Than The "No-Glare" Laws

These Cars All Equip With Warner-Lenz

Ohio Electric
Doble Steam
Stutz
Daniels 8
McFarlan
White
Marmon
Peerless
Murray
Lenox
Rock Falls
Hal Twelve
Standard 8
Case
Cunningham
Anderson
Westcott
Packard
Fiat
Crawford
Davis
Moon

MOTOR TRUCKS
Vim

Some 60 lenses now are law-complying. To merely meet the laws, any of them will serve.

But there are many other factors, all as important as the legality of the lens, to consider in selecting the lens to use. And it is the way in which Warner-Lenz meets every requirement of safety and comfort in night driving that has won its place as the foremost lawful lens.

Judge This Lens from the Driver's Seat

The proper way to choose a lens is not in laboratory tests—but on the open road and from the driver's seat. In this way you test the lens under the conditions it will be called upon to meet.

The Warner-Lenz is 176 lenses in one—scientifically staggered to diffuse the light. The result is a flood of light instead of a narrow restricted shaft. Near and far, the road, the roadsides, the ditches, the upgrades and the downgrades, the curves and turns are lighted in a way no restricted light can match.

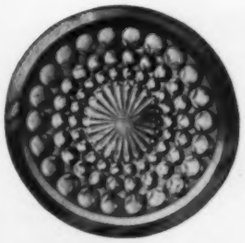
The Warner-Lenz is legal under every law. Its glareless light has no limitations. There is no direct beam so there is no height restriction. Warner-Lenz lights important signs—railroad crossing signs and others—which are usually more than 42 inches high.

Rise and fall of the car does not affect the light from Warner-Lenz. Neither does turning of the lens in the lamp-rim nor a light bulb out of focus. These points are vitally important.

The Engineer's Lens

23 leading car manufacturers have adopted Warner-Lenz for standard equipment on all their cars. In each case their leading engineer endorsed it as the best way of lighting the road at night.

This verdict should mean much to you. It stamps the Warner-Lenz as the logical lens to use.



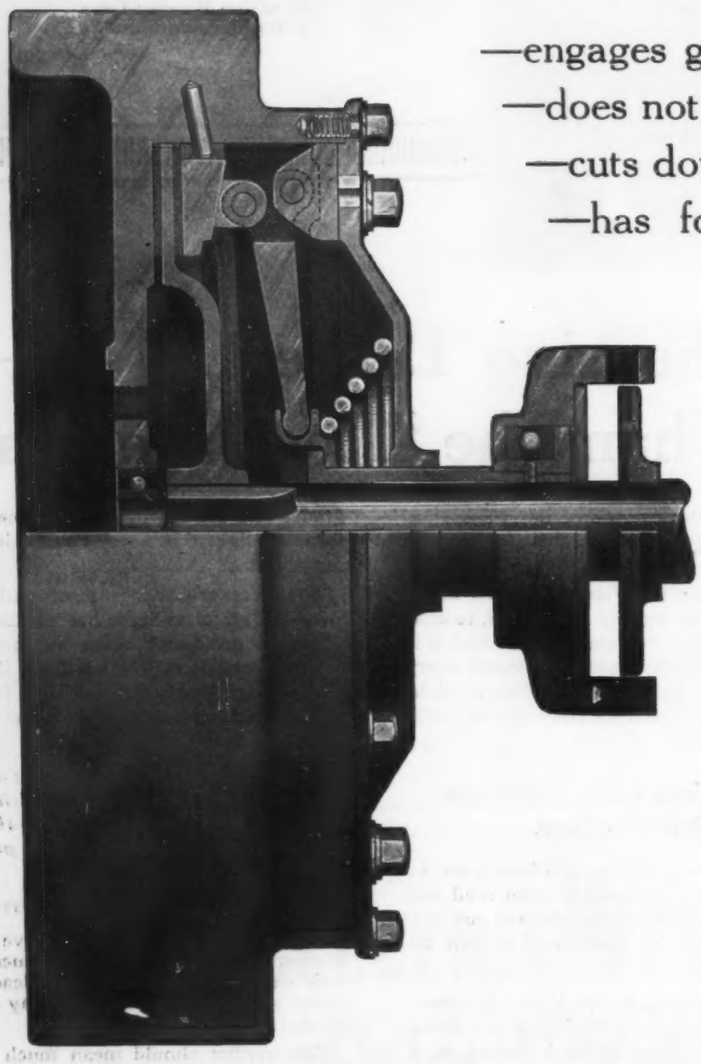
WARNER-LENZ

This is A. P. Warner of the Warner Auto-Meter Fame and Inventor of the Magnetic Speedometer.

The Warner-Lenz Company
921 S. Michigan Ave., Chicago

BORG & BECK

Single Plate Dry Clutch



—engages gradually
—does not grab, stutter or slip
—cuts down gear shifting
—has fool-proof adjustment

The *merits* of this clutch have made it standard in the *truck, tractor* and *automobile* industry—over 200,000 now in use—by over 150 leading manufacturers

Furnished to fit all standard motors and unit power transmissions.

THE BORG & BECK COMPANY

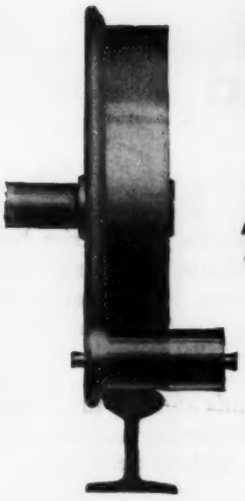
MOLINE, ILL.

Largest exclusive clutch manufacturers

BORG & BECK MOLINE, ILL.

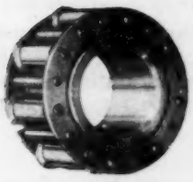
BOWER SAVES POWER

The Same Flange Principle in Both



At every hour of the day and night, 200-ton locomotives, traveling a mile a minute or more, are held on the track and guided around curves by the flanges on the wheels.

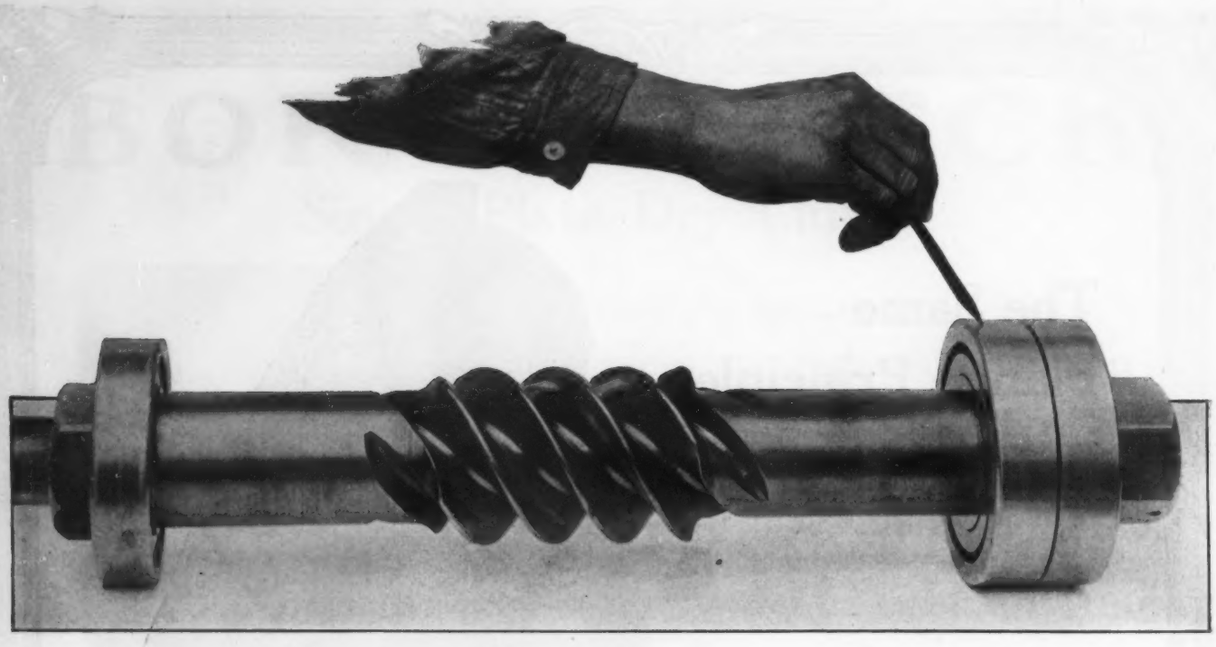
The same flange principle is used in Bower Roller Bearings to guide the rolls and resist end thrust.



BOWER

ROLLER BEARING CO.

Detroit Michigan



2600 Pounds Thrust Load at 3600 r. p. m.

The Gurney Duplex Bearing at the right of the illustration carries both the radial and thrust loads on the outer end of this high-speed worm shaft. The worm is direct-connected to a 150 h.p. Terry Steam Turbine operating at 3600 r.p.m. The worm gear reduction is made by the Cleveland Worm Gear Company, Cleveland, Ohio.

The radial load on the duplex bearing is 1075 pounds and the thrust load is 2600 pounds. Gurney Bearings are used on this job because no other type of bearing will carry these heavy thrust loads at such a high speed.

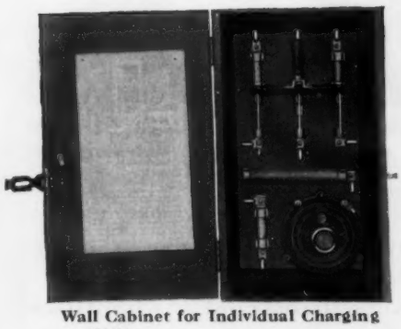
This type of worm mounting is used in the drive for the Fordson tractor and has also been adopted by a leading manufacturer of worm-drive truck axles.

Give us an opportunity to explain why the Radio-Thrust type of bearing is so much more efficient for high-speed work than the plain thrust bearing.

Gurney Ball Bearing Co.
Conrad Patent Licensee
Jamestown, N. Y.

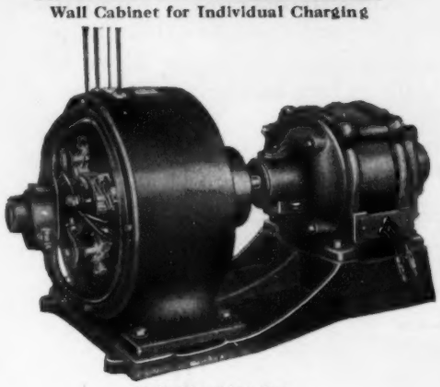
266-B

GURNEY

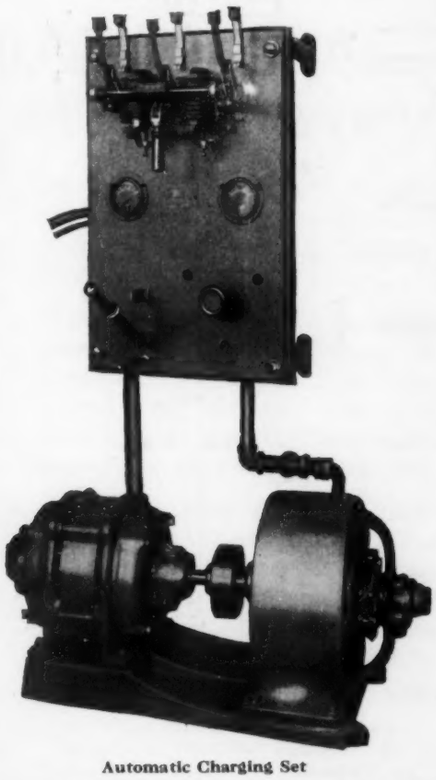


Wall Cabinet for Individual Charging

Same With Instruments



G-E Charging Set



Automatic Charging Set

Battery Charging Equipment for the Private Garage

This equipment is designed especially for charging the battery of an Individual Electric Vehicle in a private garage, but it may be adapted to the public garage which desires equipment to charge only one car at a time.

The outfit is simple to operate. After inserting the charging plug in the receptacle on the vehicle, close the switch in the wall cabinet. After the charge is properly started no further attention is required until the battery is charged, then opening the switch and disconnecting the charging cable from the vehicle completes the operation.

The cabinet with instruments is for those cases where an ammeter and voltmeter with the charging equipment are desired.

Automatic Equipment

This automatic panel is designed to open both the motor and generator circuits when battery has been charged to the extent for which the **ampere-hour meter on vehicle has been set.**

The motor-generator starts from the battery and therefore does not require any starting device for the induction motor. This insures correct polarity of the charging current.

These outfits have been standardized for charging the regular batteries (Edison or Lead) in use on electric vehicles.

General Electric Company

General Office: **Schenectady, N. Y.**

Sales Offices in all large cities 7432

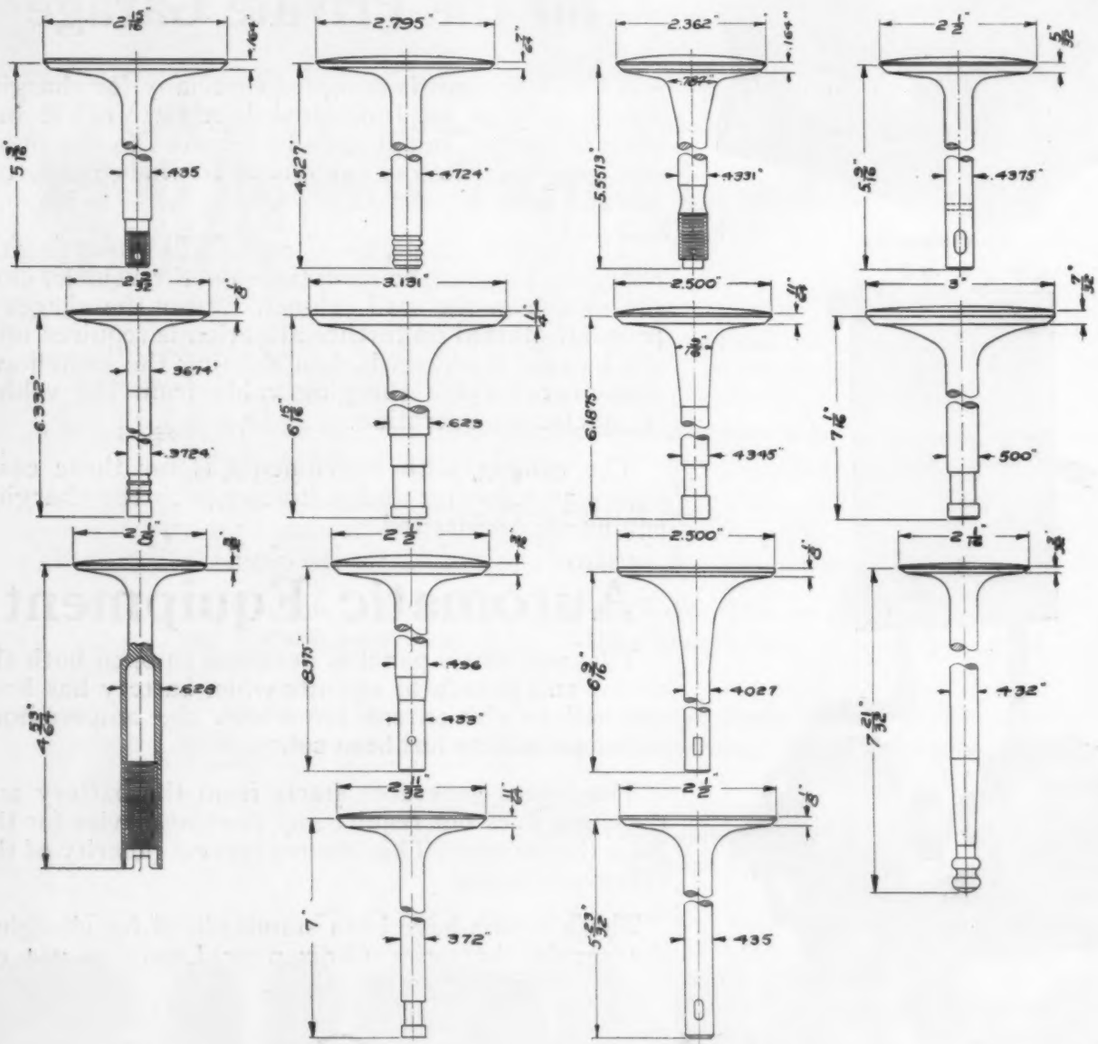
RICH TOOL COMPANY

Kresge Building, Detroit, Mich. **Railway Exchange Bldg., Chicago, Ill.**

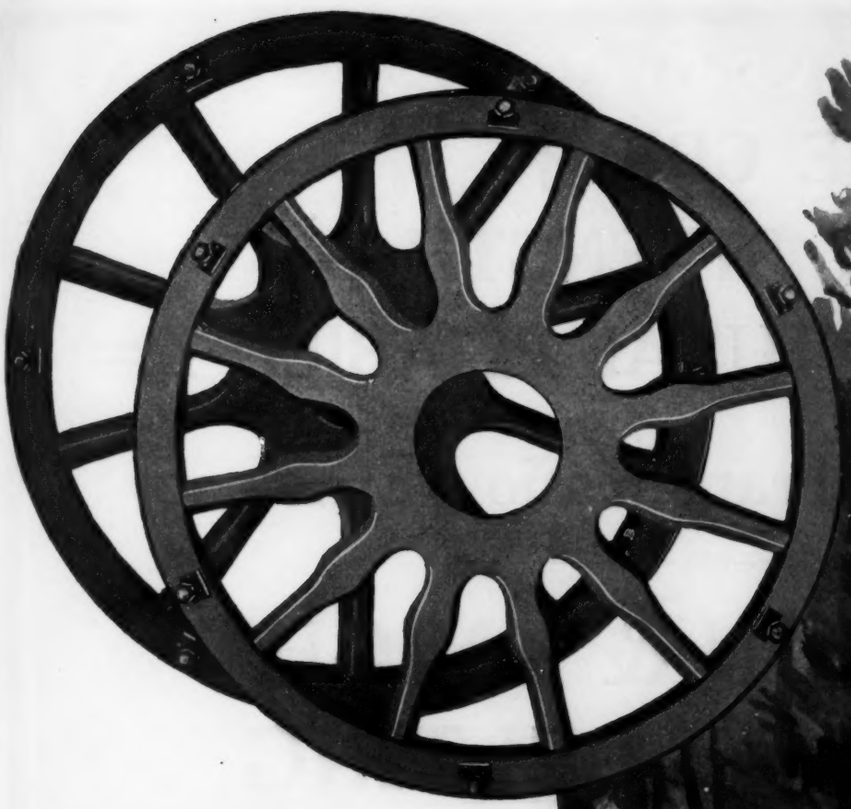
The cuts below represent valves used in some of the best known present day Aeroplane, Motor-Boat and Racing Automobile Engines. They are all products of this company and most of them have been produced in large quantities and have, therefore, been thoroughly tested in service.

Needless to say, they are all Tungsten Steel, but we also make one-piece forged valves of all other commonly used Alloy Steels in the manufacture of which we exercise the same care as is used in higher priced Tungsten Valve materials.

One of the newer types of valves which we have been making in very large quantities for the past year is our Hi-Chromium Valve, which has some very remarkable properties. It is for some purposes an excellent valve and we solicit inquiries from those who are troubled by a persistent burning away of the seats of the valves in their motors.



Our Engineering Department is at your service on all questions concerning suitability of material and design.



20,000,000,000 feet of hickory

At the present time, it is estimated that there are twenty billion feet of standing hickory timber in the United states.

Twenty billion feet—a quantity utterly incomprehensible in its magnitude—means that the supply of hickory for the making of wood wheels for passenger cars is inexhaustible.

It means that the best passenger car wheels for all time to come will be made from hickory—the hard, tough, close-grained, resilient wood that has been proved by centuries to make the most efficient wheels.

AUTOMOTIVE WOOD WHEEL MANUFACTURERS ASSOCIATION
105 NORTH 13th ST. PHILADELPHIA

WOOD WHEELS for MOTOR VEHICLES

POSITIVE GRIP +
GREAT STRENGTH +
NATURAL PLIABILITY =

Maximum Transmission Efficiency

GRATON & KNIGHT LINK "V" BELTING

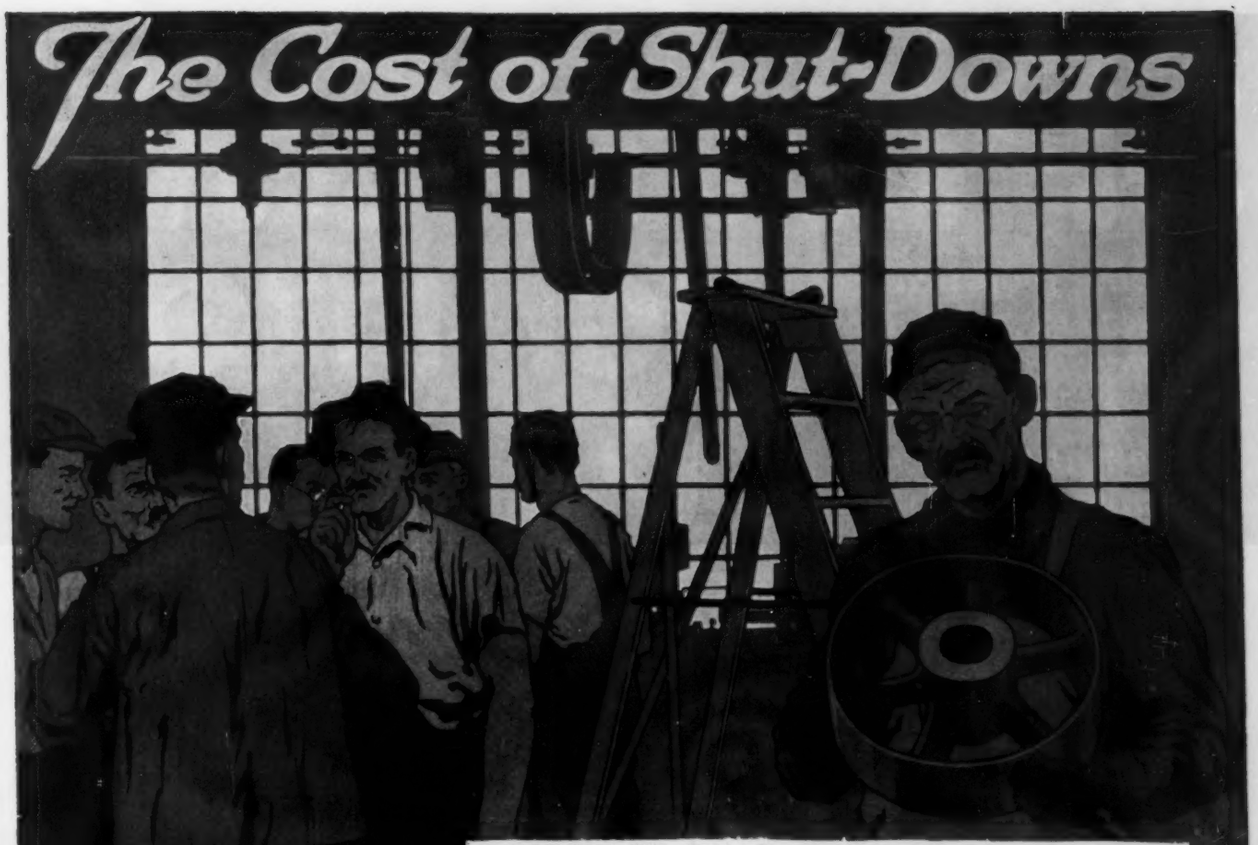
combines these qualities to a much higher degree than any other form of power transmission. In addition they are absolutely noiseless in operation—require no belt fasteners, and are easily shortened. So tightly does a G & K Link "V" Belt hug the sheaves that it will drive when quite slack—thus reducing journal friction on bearings. Constructed from metal and leather, these belts are practically indestructible—another item which adds to their economy of operation.

For complete information and prices send blue prints or specifications to the Engineering Department of

THE GRATON & KNIGHT MFG. CO.
WORCESTER, MASS.

Branches in All Principal Cities

The Cost of Shut-Downs



© 1918 Arguto Oilless Bearing Co.

No. 5 of a Series

THE best bargain is one that benefits both sides equally.

Arguto Oilless Bearings cost you from ¼ to ⅓ less than bronze or other metal bearings when you *first* install them; but they continue the saving right along. The final cost is less than 1/50 of bronze, because Argutos outwear any metal bearings. They run continuously from 8 to 15 years.

They need no oil, no attention.

They take no days off that cause the shut-down of even one machine.

They keep your men away from moving machinery, lowering the life hazard in the plant and improving the feeling of confidence and safety in the men.

They are equally suitable for low or high speeds. They do not run hot, and in loose pulleys will not perceptibly wear the shafting even after years of continuous operation.

Our side of the bargain comes from securing permanent customers because Argutos have saved them money and because they are uniform in the quality of material and in workmanship.

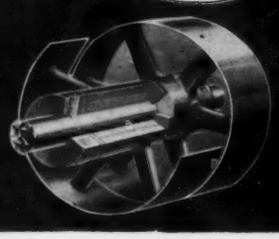
If you have a troublesome bearing in your plant, write for our special trial offer, sending the inside and outside diameters and the length.

Arguto Oilless Bearing Company
156 Berkley Street
Wayne Junction Philadelphia

Arguto

SMOOTHER THAN GREASE

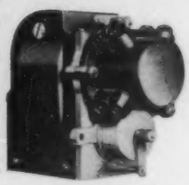
OUTWEARS THE BEST BRONZE METAL



ARGUTO
OILLESS BEARINGS

SPLITDORF IGNITION DEVICES

The only thoroughly American manufacturer producing a complete line of devices for gas engine ignition purposes . . . . .



DIXIE
8-cyl. Magneto
DIXIE Magnetos are made in 1-cyl., 2-cyl., 4-cyl., 6-cyl., 8-cyl. and 12-cyl. Types

DIXIE MAGNETOS

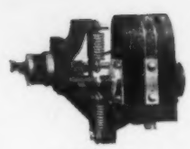
Dixie simplicity of construction, its accessibility, its dependability under all stress and rack of road and general working strain—the quick pick-up and instant get-away inherent to it—have made it a household word for ideal ignition. For passenger cars, for trucks, for aeroplanes, for motorcycles, for tractors, for motorboats.

There's no revolving wire in a DIXIE—there's the same spark at retard as advance—the breaker is accessible with the engine running—there's simplicity and effectiveness in every DIXIE detail.

SUMTER PLUGOSCILLATOR

permits easy starting in stationary engines of practically any size. It is used on stationary engines and the hot intensity of its spark is independent of the rotating speed of the engine. It is a unit in itself—readily replaceable when necessary by another unit of like construction, just the same as a spark plug can be replaced in a cylinder head.

SUMTER Plugoscillators lighten the farmer's burden of difficult starting—make it practically unnecessary for him to give his attention to making delicate and not easily understood adjustments and give him unfailing service.



SUMTER
Plugoscillator
for easy starting of stationary engines

Back Connected Volt or Ammeter

VOLTMETERS, AMMETERS AND COMBINATION VOLT-AMMETERS

The construction of Splitdorf instruments is such that they stand enormous vibration tests without injury. The moving parts operate in jewels, with highly polished hardened steel pivots set in German silver posts. They are dust, moisture and air tight, and are accurate to within two per cent.

They are rapid acting and thoroughly damped; not over two oscillations or overswings of the pointer are noticeable, the hand then comes to a dead standstill.

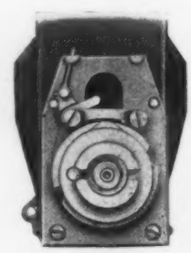
SUMTER STARTER-COUPLING

This little device which is purely mechanical does away with the use of batteries for making a starting spark on those engines which cannot be cranked very rapidly.

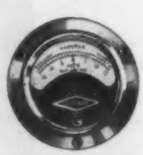
It makes starting SAFE because the spark is automatically retarded; SURE because the spark is hot, due to an almost instantaneous high rotative speed of the magneto motor; EASY because you do not have to turn the engine rapidly.

Many farm tractors carry this Starter-Coupling as standard equipment.

And trucks, aeroplanes and marine motors without starting devices can be equipped with this Starter-Coupling to make the starting of the heaviest motors easy, sure and safe.



SUMTER
Starter-Coupling
makes starting SURE and EASY



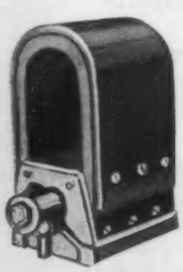
Flush Type Volt Ammeter

SUMTER LOW-TENSION MAGNETOS

The SUMTER line of low-tension magnetos is prominent in the stationary engine field for the thousand and one utilitarian purposes to which gas engines are universally applied.

SPLITDORF SPARK PLUGS

"The Plugs with the Green Jacket"—are made in all sizes and types for every engine. There is a particular plug that is best suited for every engine, be it an automobile, a tractor, a motorcycle, a truck, an aeroplane, a motorboat or farm engine. SPLITDORF SERVICE will tell you the *right* plug and you can get it from any dealer.



SUMTER
Type "AGD" Low-Tension Magnetos

"The Plug with the Green Jacket"

Sumter Electrical Co.
1466 Michigan Ave.
Chicago, Ill.

Splitdorf Electrical Co.
Newark, N. J.

BRANCH HOUSES AND SERVICE STATIONS:

Atlanta	10-12 E. Harris St.	Newark	278 Halsey St.
Boston	68 Brookline Ave.	New York	7 W. 61st St.
Chicago	2613 S. Michigan Ave.	Philadelphia	210 N. 13th St.
Dallas	402 S. Ervay St.	Pittsburgh	5943 Ellsworth Ave.
Detroit	1295 Woodward Ave.	San Francisco	1022 Geary St.
Kansas City	1827 Grand Ave.	Seattle	1628 Broadway
Los Angeles	1215 S. Hope St.	Toronto	469 Yonge St.
Minneapolis	816 Hennepin Ave.		

ATLAS STEEL BALLS

For Reliability

In any machinery where life and reliability of service depend upon its bearings, Atlas Alloy Steel Balls will give superior satisfaction.

The Atlas process of heat treating and finishing produces balls capable of withstanding extreme stresses, yet running smoothly, with minimum wear or frictional resistance.

Use Atlas Alloy Steel Balls. We guarantee their quality and your satisfaction

ATLAS BALL COMPANY

Glenwood Ave. at Fourth St.

Philadelphia, U. S. A.

Accuracy-

THE slogan of our grinding shops is "accuracy." When existing machines would not give close enough results for certain operations we invented new machines.

To get greater accuracy in truing our grinding wheels we devised entirely new truing apparatus. We aim to make our products in every way worthy to enter into the construction of yours.

No chance enters into our grinding department. Every dimension of your special valves, bolts, screws and other parts is accurately finished—gauged—KNOWN.

A DEPARTMENT OF YOUR PLANT FOR

Motor Valves
Spring Shackle Bolts
King Bolts
Chassis Bolts
Connecting Rod Bolts
Push Rods or Valve Tappets
Drag Links
Brake Rod Assemblies
Starting Cranks
Lamp Brackets
Tank Straps
Propeller Tubes
U. S. S. Head Cap Screws
Piston Pins

The Steel Products Co.

Michigan Plant
Detroit, Mich.

Main Plant
Cleveland, O.

Metals Welding Plant
Cleveland, O.

GEARS & DIFFERENTIALS IN ANY QUANTITIES

For Automobile, Truck and Tractor Needs

Satisfactory performance of New Process Gears and Differentials is assured before they leave the factory. In them every possible demand of service has been foreseen and fully met.

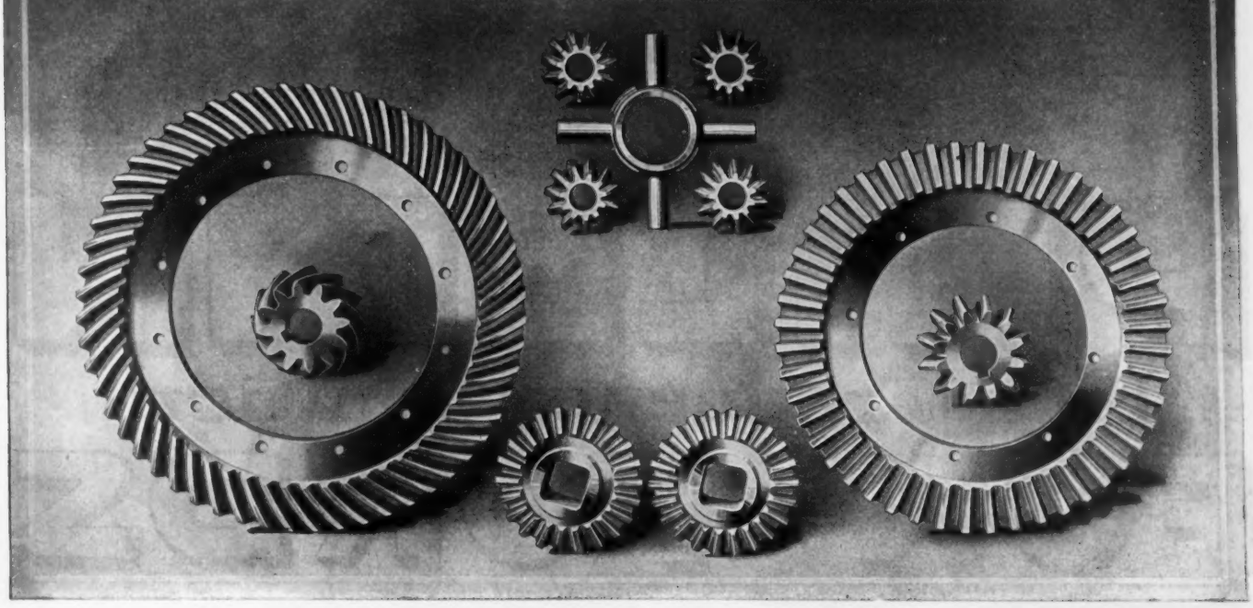
Accuracy in designing and in manufacture—29 years' experience concentrated on gear making only—the largest plant in the country devoted exclusively to gear manufacture, assure the goodness of New Process Gears.

With most of our annual production being absorbed by the automobile industry, our product must be right.

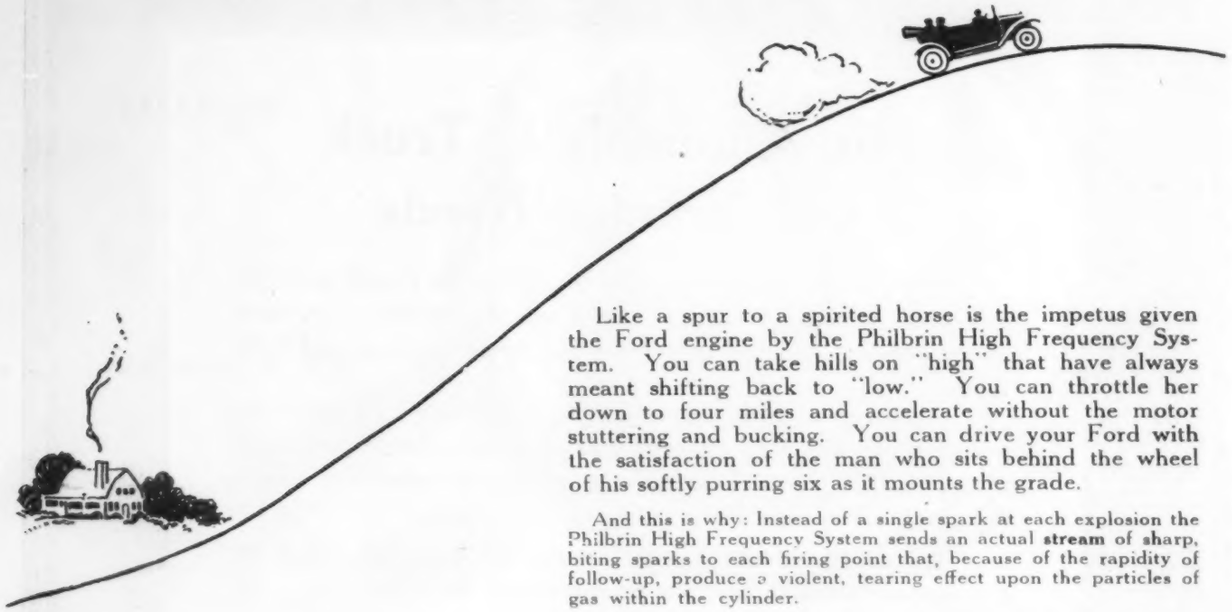
Submit specifications for estimate.

NEW PROCESS GEAR CORPORATION
SYRACUSE, N.Y

199



Over the top on "high" without a single, faltering engine stroke—that's how a Ford will perform when equipped with this more efficient ignition.



Like a spur to a spirited horse is the impetus given the Ford engine by the Philbrin High Frequency System. You can take hills on "high" that have always meant shifting back to "low." You can throttle her down to four miles and accelerate without the motor stuttering and bucking. You can drive your Ford with the satisfaction of the man who sits behind the wheel of his softly purring six as it mounts the grade.

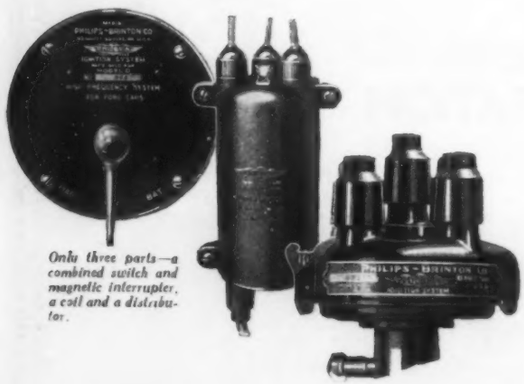
And this is why: Instead of a single spark at each explosion the Philbrin High Frequency System sends an actual **stream** of sharp, biting sparks to each firing point that, because of the rapidity of follow-up, produce a violent, tearing effect upon the particles of gas within the cylinder.

Apply the Philbrin High Frequency System and you can use a leaner mixture successfully. This system not only assures greater economy and increased power, but it also provides against any difficulty through faulty carburetor adjustment, inferior gasoline, or fouled spark plugs. Starting is also made easier as a result of the intensity and vigor of the high frequency delivery.

The Philbrin High Frequency System derives its current from the Ford magneto—no battery is necessary. Installation is easily made. Write now for descriptive folder. Plan to get every ounce of power, mileage and satisfaction out of your fuel.

Philbrin Ignition is also made in Duplex and Single Spark systems for all makes of cars.

Dealers—We desire representation on the Philbrin High Frequency System for Fords in all territories as yet unassigned. Our proposition is attractive, the field is big, the article of proven merit.



Only three parts—a combined switch and magnetic interrupter, a coil and a distributor.

PHILIPS-BRINTON COMPANY
517 SO. BROAD ST. KENNETT SQUARE, PA.

PHILBRIN
High Frequency Ignition
FOR FORDS

The Control of Quality
Point No. 11

Getting the Third Degree

Cups, cones and rollers of a Timken Bearing are heated to just the right red heat before hardening — and this temperature is automatically regulated.

Motion of the parts in the furnace is so timed that a single trip through the heat brings the temperature of every piece up to just the proper point.

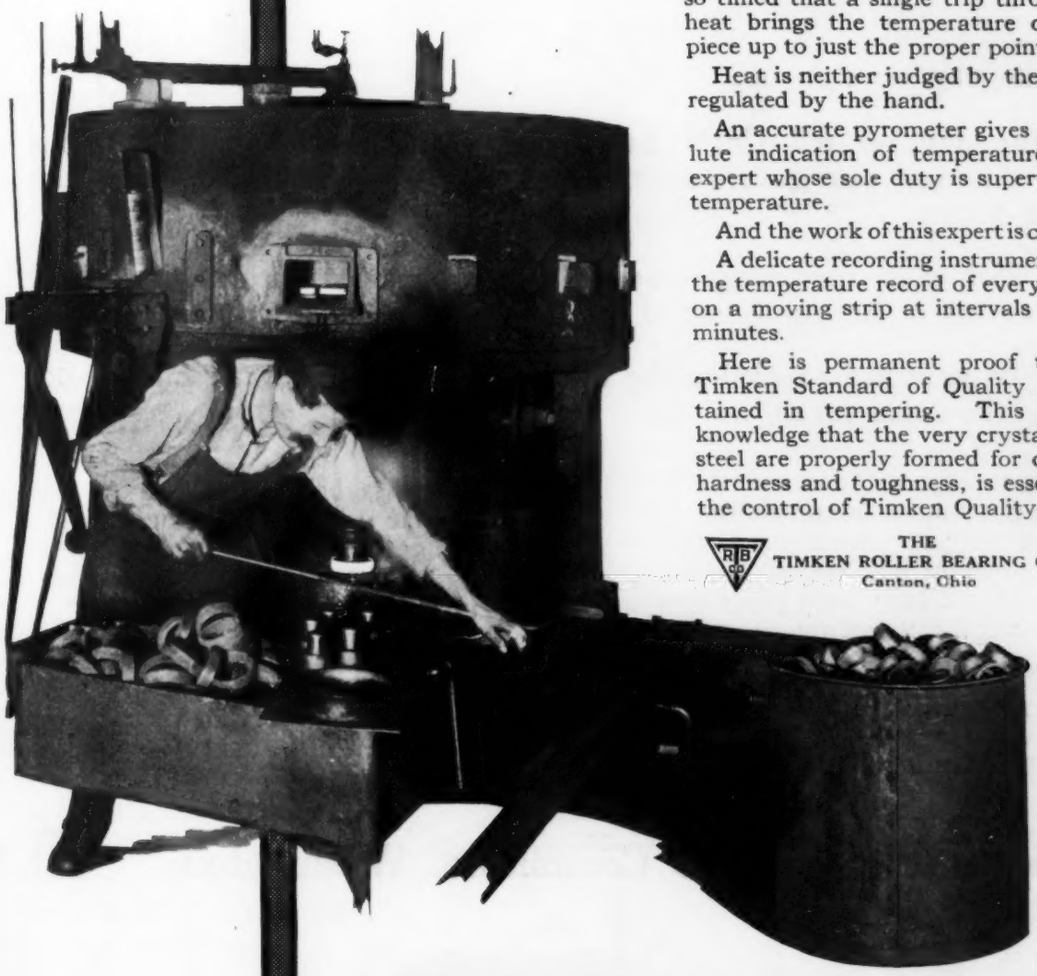
Heat is neither judged by the eye nor regulated by the hand.

An accurate pyrometer gives an absolute indication of temperature to an expert whose sole duty is supervision of temperature.

And the work of this expert is *checked*.

A delicate recording instrument prints the temperature record of every furnace on a moving strip at intervals of a few minutes.

Here is permanent proof that the Timken Standard of Quality is maintained in tempering. This absolute knowledge that the very crystals of the steel are properly formed for combined hardness and toughness, is essential for the control of Timken Quality.



THE TIMKEN ROLLER BEARING CO.
Canton, Ohio

TIMKEN BEARINGS

National War Savings Day June 28th

That's the day we sign up.

That's the day we tell Uncle Sam just how hard we want to win this war. That's the day our government has officially set for us to purchase War Savings Stamps.

On June 28th every man, woman and child in the United States will be called upon to pledge his or her full quota of War Savings Stamp purchases for 1918.

You will be expected to pledge the **full** amount that you can afford—no more—but by the same token, no less.

In every state, county, city, town and village the War Savings Committees are preparing for this big patriotic rally of June 28th. Unless you have already bought War Savings Stamps to the $1,000 limit, get busy with paper and pencil and figure out the **utmost** you can do.

Remember this. You take no chances when you go the limit on War Savings Stamps. They are the best and safest investment in the world. They pay you 4% interest compounded quarterly. They **can't** go below par. You can get back every dollar you put into War Savings Stamps **any time you need it.** You can turn them in at the Post Office **any time** for their full value plus interest.

Uncle Sam is asking hundreds of thousands of men to **give** their lives to their country. He is asking you only to **lend** your money.

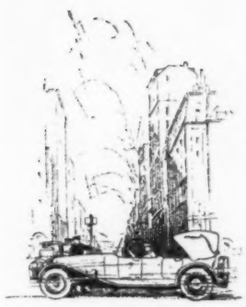
What are **you** lending?

National War Savings Committee, Washington.

W.S.S.
WAR SAVINGS STAMPS
ISSUED BY THE
UNITED STATES
GOVERNMENT

Contributed through Division of Advertising — *United States Gov't. Comm. on Public Information*

This space contributed for the Winning of the War by
THE SOCIETY OF AUTOMOTIVE ENGINEERS



Send for this valuable brake lining chart

Every member of the Society of the Automotive Engineers should have in his files one of the new Thermoid Brake Lining Charts. This chart shows you instantly the sizes and amount of brake lining and clutch facings needed on any car. It also lists the type of brakes on each. It covers all the standard cars and motor trucks and all the models of each car for three years.

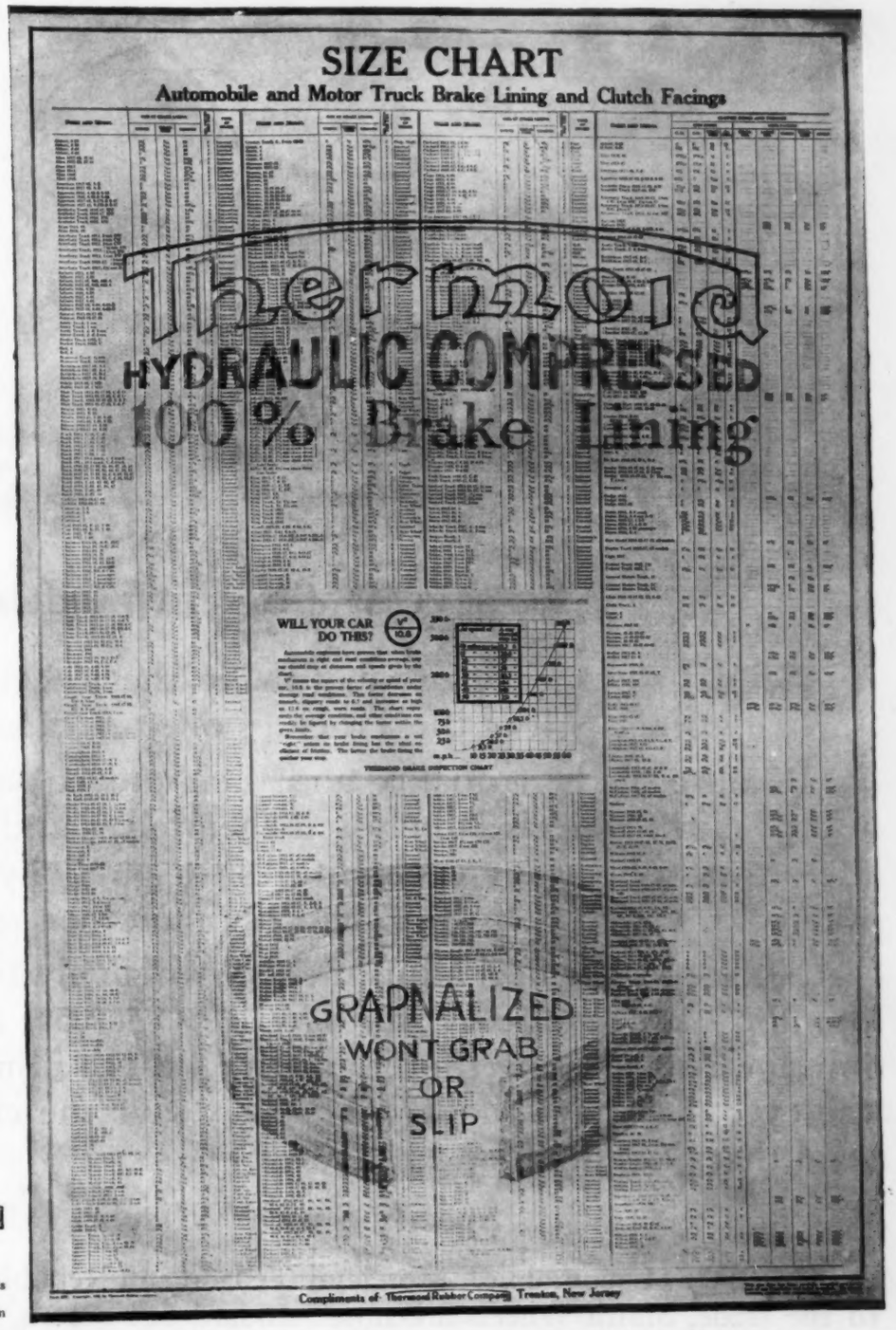
It also contains a chart showing how quickly cars should stop with brakes applied when going at various speeds. It is a quick convenient reference chart which will be sent free to members of the Society of Automotive Engineers.

Thermoid Rubber Company

Factory and Main Office: Trenton, N. J.

Branches:

New York Chicago San Francisco Indianapolis Detroit Los Angeles Philadelphia Pittsburgh Boston London Paris Turin



THERMOID RUBBER CO.
Trenton, New Jersey
Dept. 15

Please send me your *free* chart showing sizes of brake linings for passenger cars and motor trucks

Name _____ Street _____

City _____ State _____

GMC TRUCKS

standard on

Smith Wheels

"EVERLASTING"

for several different models

SERVICE exactions to-day make the wheels just as vital as any other part of the Truck of one-ton capacity and greater.

Because of their quality and their proved satisfaction to the user, Smith Wheels largely sell themselves and the Truck they are on without heavy expenditures for publicity, and keep both well sold, which helps the chances of another sale.

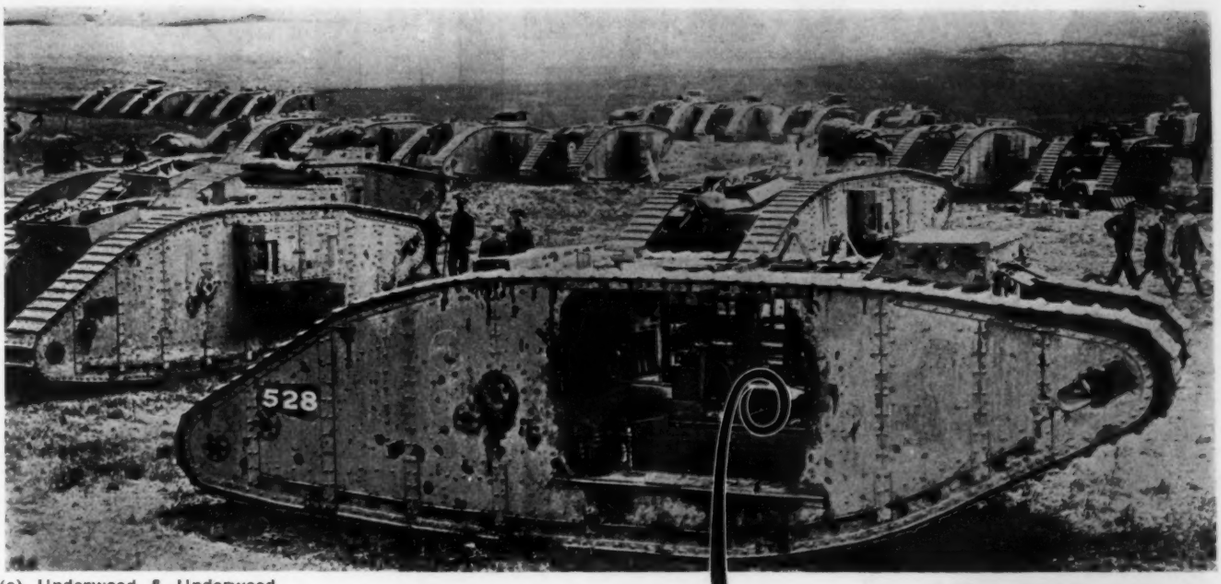
None of the wheel adjustments—which always mar the user's opinion—are required. Smith Wheels increase tire and gasoline mileage and prolong the life of the Truck. Smith Wheels sell the eye, they have the GUTS, they save the customer money. And that goes double!

Specify Smith Wheels.

On Riker (Locomobile), Moreland, Federal and Republic, so far announced to the trade, Smith Wheels are now standard equipment. Many other well-known makes will be given page publicity in turn.

We're there with the punch on Quality and Delivery.

SMITH WHEEL INC
SYRACUSE, N.Y. U.S.A.



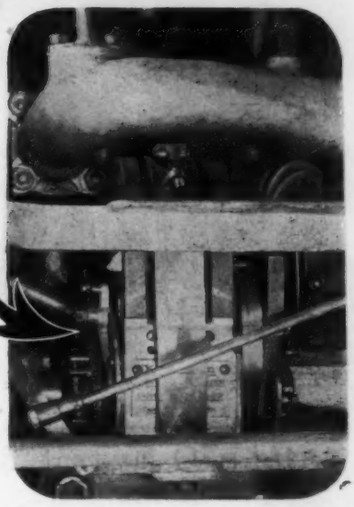
(c) Underwood & Underwood

Thousands of British Tanks Trust the Reliability of K-W Magnetos

This official photograph, taken after the famous battle of Cambrai, shows a squadron of British Tanks somewhat battered but still able to return under their own power after covering miles of seemingly impassable shell craters and trenches.

It is significant that the British Government trusts the reliability of K-W Magnetos, an American product, to furnish the very nerves of these and thousands of British Tanks.

When the English Engineers designed the first Tank, they knew that the Tank service would be too severe for automobile or truck magnetos. So they turned to tractor service and selected a K-W—a Magneto which had proven through years of service on tractors, that it had the rugged construction, the efficiency and the built-in reliability, to stand up in Tank service.



Model H K
K-W HIGH TENSION MAGNETO

K-W Magnetos made good, because they were built for just that kind of service. Today, thousands of model HK Magnetos are keeping Allied Tanks agoing in the most gruelling service known. Here at home, K-W Magnetos are keeping tens of thousands of Peace Tanks (Farm Tractors) agoing.

Insist upon reliable ignition, proven in Tank and Tractor service. Then you can be assured that your customers will not have their tractors laid up with ignition trouble.

Write for list of K-W equipped tractors (there are 83 models) and full information regarding K-W Magneto.

THE TRADE K-W MARK IGNITION Co
2843 Chester Ave. CLEVELAND, OHIO, U.S.A.

TRADE K-W MARK

BAKELITE

REG. U. S. PAT. OFF.

Heat "Freezes" It

"TO say that 'Bakelite freezes' when subjected to heat is merely a homely way of describing that property singular to Bakelite which the chemist sums up in the one word—exothermic.

In plain language, heat applied to Bakelite granular powders or plastic sheets first fuses and then solidifies them. The resultant substance is smooth, hard, homogeneous, non-hygroscopic and will not bloom, crack or otherwise deteriorate with age.

The further application of heat will not affect Bakelite, because the finished product withstands temperatures up to the point of carbonization without melting or even appreciable softening. This heat resistant property is extremely valuable—for instance, wire leads can be readily and safely soldered to metal inserts moulded into Bakelite articles.

Bakelite is mechanically and dielectrically strong and chemically inert. It is unaffected by water, steam, oils, solvents and most chemicals."

The GENERAL BAKELITE COMPANY, 2 Rector Street, New York, welcomes inquiries from manufacturers and maintains a research laboratory for the working out of new applications.

2003-B

PERFEX

The Perfect Radiator

For Tractors, Trucks and Commercial Cars

Built for Sturdy Service!

PERFEX Radiators are built for durability! Each one is constructed for dependable service under all conditions. Each is made of best materials, by master workmen.

Perfex Radiators are scientifically constructed. The extra strong bonded joints are far superior to the old method of soldering lap jointing. The flexibility of the exclusive "Expansion Slit" takes up all jolts and jars of heaviest service. This "Expansion Slit" also protects radiator from damage to accidental freezing in winter.

Extra large unobstructed water channels insure perfect cooling service. No fins—no clogging. Every square inch of surface cools!

We are equipped to build a special Perfex Radiator for your motor. All Perfex Radiators are made to order after careful analysis of the motor and its heaviest service. Write for information about our free service to motor manufacturers.

Perfex Radiator Co.

604 Flett Ave., Racine, Wisconsin

Johns-Manville

THE one thing in brake lining that counts most for dependability and long life is the quality of the asbestos that goes into it. That is why Non-Burn has the advantage over other brake linings in being made by the world's greatest manufacturers of asbestos products.

NON-BURN ASBESTOS BRAKE LINING

LONG before the day of the motor car, Johns-Manville engineers had learned how to make dependable brake lining for giant industrial machinery. And so the tremendous and sudden demand for automobile brake lining found them years ahead of competition, both in command of the best raw material and in knowledge and experience in the process of manufacture.

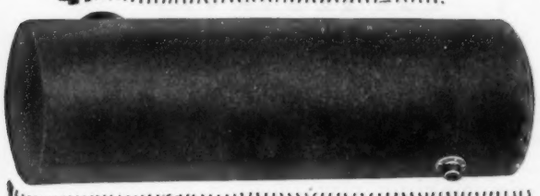
The strong, tough fibres of Asbestos that are woven with wire into Non-Burn Brake Lining come from Johns-Manville's own mines and represent the highest grade of asbestos mined anywhere in the world.

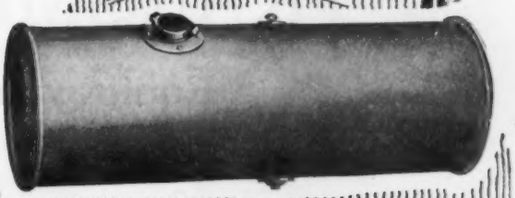
H. W. JOHNS-MANVILLE CO.
NEW YORK CITY
10 Factories—Branches in 61 Large Cities

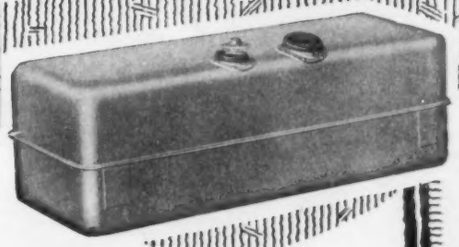
When you think of Asbestos you think of Johns-Manville

GASOLINE TANKS

MADE TO YOUR SPECIFICATIONS







In our special tank department we make all types of gasoline tanks, welded or lock-seamed—build them to your particular requirements. Many large automobile manufacturers come to us because they know that G. P. & F. Tanks are of dependable quality, equal to the high standard of their own product. In addition to this they have found that

G.P.&F. SERVICE
"KNOWING HOW SINCE '81"

means prompt deliveries and reasonable prices, effecting worth-while economies in the cost of their completed product.

It is very likely that you, too, can enlist G. P. & F. Service to your advantage. The buying and manufacturing facilities of our large plant covering 15 acres, together with our 36 years of experience in making pressed steel parts, are at your service.

Send blue-print or sample or give us specifications on the kind of tank you require and let us submit figures

GEUDER, PAESCHKE & FREY CO., 1365-1700 St. Paul Ave., Milwaukee, Wis.

Detroit Representative: Mr. R. W. Angstman,
1312 Dime Bank Bldg.

"WHITNEY"

COTTER TYPE

TRANSMISSION CHAINS

Equip your Motor Trucks and Tractors with "Whitney" Chains

Our years of experience in chain making, our selection of only the best materials, our special processes of manufacture, and our rigid system of inspection, all combine to make "Whitney" chains the leaders in their line.

Now that the motor truck is handling so much of the freight that was formerly cared for by the railroads, it must run on a schedule almost as exacting as that of the railroad train itself. This emphasizes the necessity of selecting a chain which can be relied on under all conditions of speed, road, and weather.

ON THE BATTLE FRONTS OF EUROPE

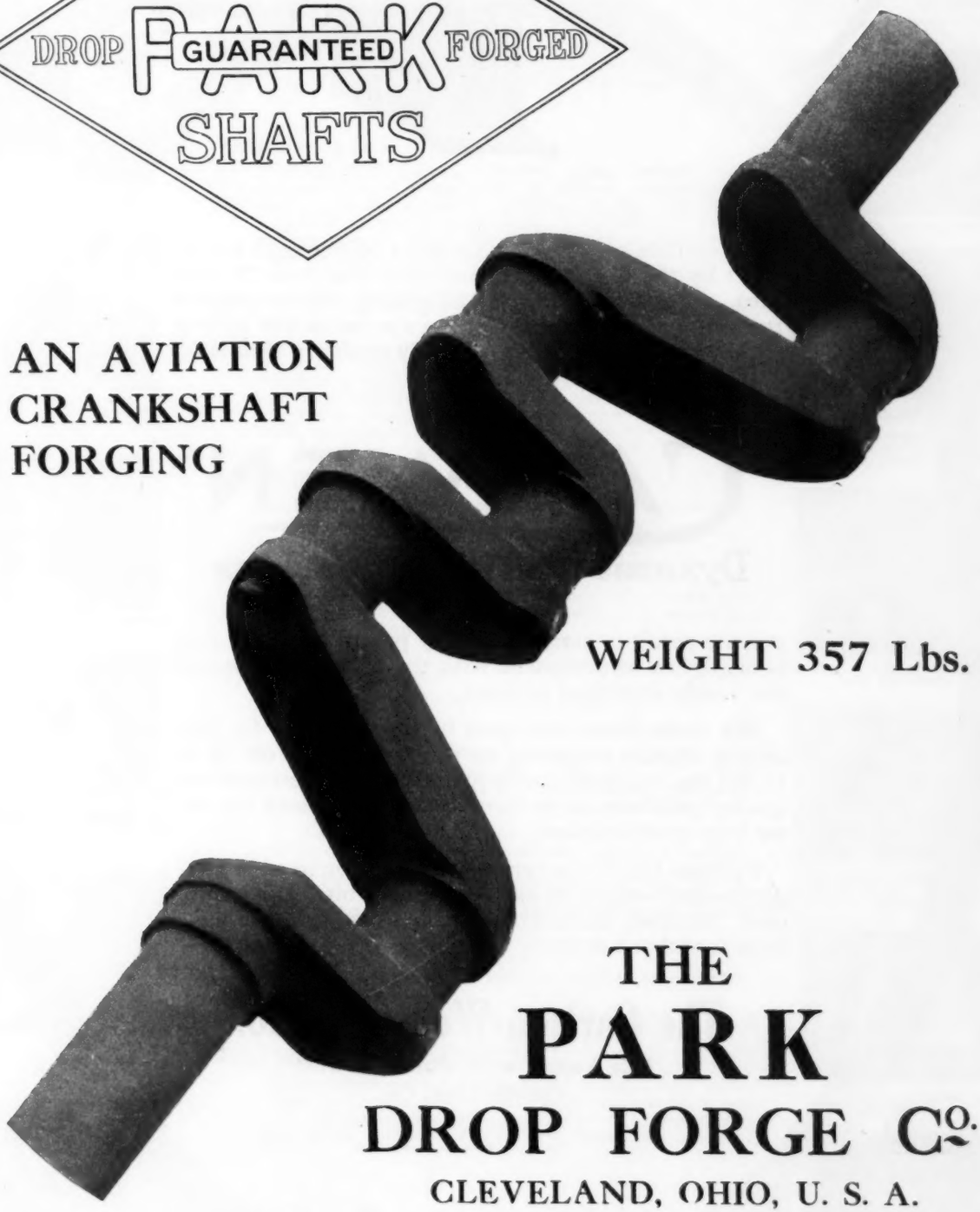
Tens of thousands of "Whitney" chains are "doing their bit" where dependability is the all-important factor and where failure may spell disaster.

THE WHITNEY MFG. CO. Hartford, Conn.

CHAINS KEYS AND CUTTERS HAND MILLING MACHINES

CRANK
DROP PARK GUARANTEED FORGED
SHAFTS

AN AVIATION
CRANKSHAFT
FORGING

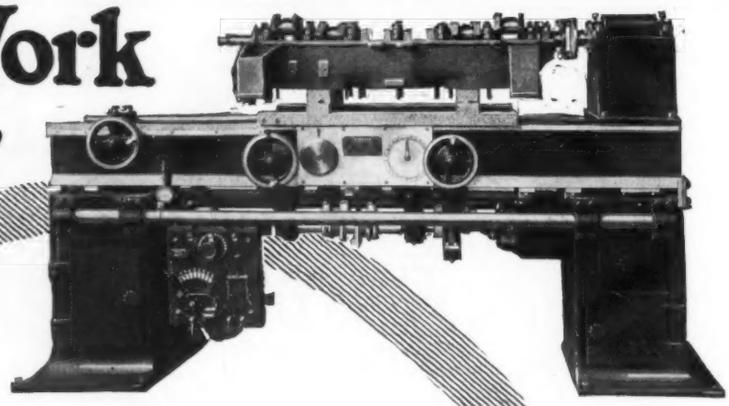


WEIGHT 357 Lbs.

THE
PARK
DROP FORGE Co.
CLEVELAND, OHIO, U. S. A.

We Have Shipped 63,081 Counterbalanced Crankshafts to June 7th, 1918

Precision Work in Quantities



The entire process of accurately balancing a crankshaft by the Carwen method takes less than 20 minutes. This includes static balancing, measuring the running unbalance and drilling the holes (or adding metal) needed to correct it. Only ordinary skill is required with the

CARWEN
Dynamic Balancing Machine
(AKIMOFF PATENTS)

yet the result is mathematically precise, and the cost is negligible as compared with the gain in output and the vastly improved product.

We make these machines in sizes suitable for balancing objects weighing all the way from 5 oz. up to 15,000 lbs. and their use is just as practical on medium quality products as on those where price does not enter into consideration.

Perhaps this is the very equipment you need in your plant—such concerns as Overland, White, Ford, Simplex, Mitchell, General Electric, Westinghouse, etc., have found one or more "Carwens" necessary.

The Carlson-Wenstrom Co.

Erie Avenue at Richmond Street
Philadelphia, Pa.

Illustrated Booklet describing the principle involved and its application sent upon request

Makers also of CARWEN Double Row Ball Bearings

Relining gas producer with Hytempite and crushed old fire brick.

Forms in place, reverberatory smelting furnace, ready for lining.

Mixing Hytempite with old crushed fire brick for making rammed-in lining for smelting furnace.

Ramming-in lining, smelting furnace.

Crucible before repairing and surfacing with Hytempite.

Same crucibles after being repaired and resurfaced with Hytempite.

Bridge wall in boiler laid with Hytempite.

THINGS YOU SHOULD KNOW ABOUT

HYTEMPITE

(REG. U. S. PAT. OFF.)

What is it?

HYTEMPITE is a scientifically compounded refractory plastic material for bonded fire brick and kindred uses.

What does it do?

HYTEMPITE forms a lasting union between the materials to be joined, sets at normal temperatures and retains its strength regardless of the heat it is subjected to up to about 3100° F. (1700° C.) or a temperature at which the best quality of fire brick loses its strength and becomes soft.

Why is it better than fire clay?

HYTEMPITE is better than fire clay because fire clay and water has no binding strength, does not support the brick work or knit together the materials with which it is used, comes loose from constant expansion and contraction, disintegrates or falls out, forming crevices or cracks, and does not maintain a gas or air tight structure.

Does it depend on heat for a bond?

No, HYTEMPITE air sets at normal temperatures, making a wall of uniform strength throughout.

Will it stop or prevent air and gas leaks?

Yes, HYTEMPITE will not only stop these leaks, but will withstand the expansion and contraction caused by heat without loosening.

What proves its merit?

Over 75% of its sales are repeat orders.

What are some of its uses?

1. For laying fire brick and tile.
2. For tightening old walls and arches, sealing openings in new walls, stacks, etc., to make them airtight, lining doors, etc.
3. Hot patching in furnaces, gas retorts, etc.
4. Making special tile and shapes with crushed old fire brick or carborundum fire sand.
5. Making rammed-in linings with your crushed old fire brick or carborundum fire sand.
6. Bonding new courses or a veneer of fire brick to old walls.
7. Preventing leaks between bricks and iron work.
8. As a wash for surfacing brick work.
9. As a grout diluted or neat, according to requirements.
10. For lining ladles.
11. For patching or building up tuyeres, etc., etc.

Who makes HYTEMPITE?

An organization that has had over twenty years' experience in furnace design, construction and operation and which understands what is required of a furnace cement and stands back of HYTEMPITE, **Furnishing Personal Service.**

Quigley Furnace Specialties Co.

26 Cortlandt Street New York

Pit crucible furnace before lining.

Form in place, partially lined.

Pit crucible furnace relined with Hytempite and carborundum rammed-in.

Setting arch in small furnace with Hytempite.

Door before being repaired with Hytempite. Bricks falling out.

Furnace door repaired with Hytempite.

Shipping Hytempite.

Condensite

Stands Heavy Stress—Condensite

is largely used for molding commutators where speeding of the engine imposes great centrifugal stress.

Wherever there is need for mechanical strength, resistance to heat, ease and rapidity of molding, high finish, resistance to weathering—CONDENSITE will insure economical, satisfactory results.

Consider the commutators for starting and lighting motors and generators where speeding of the engine imposes a great centrifugal stress—CONDENSITE has proven most successful in this field. All the properties essential to good electrical insulation are found in CONDENSITE in greater degree than in any other substance.

CONDENSITE—the finished product—contains no moisture nor will it absorb any. It possesses extremely high dielectric resistance, is very hard and retains its high finish indefinitely.

Heat resisting, and odorless, it is a stable product that will not break down chemically. Has great mechanical strength in tension, compression and shear.

CONDENSITE, the plastic molding compound, is the logical solution to many intricate manufacturing problems. Pieces can be made in one operation that would be impossible by any other method.

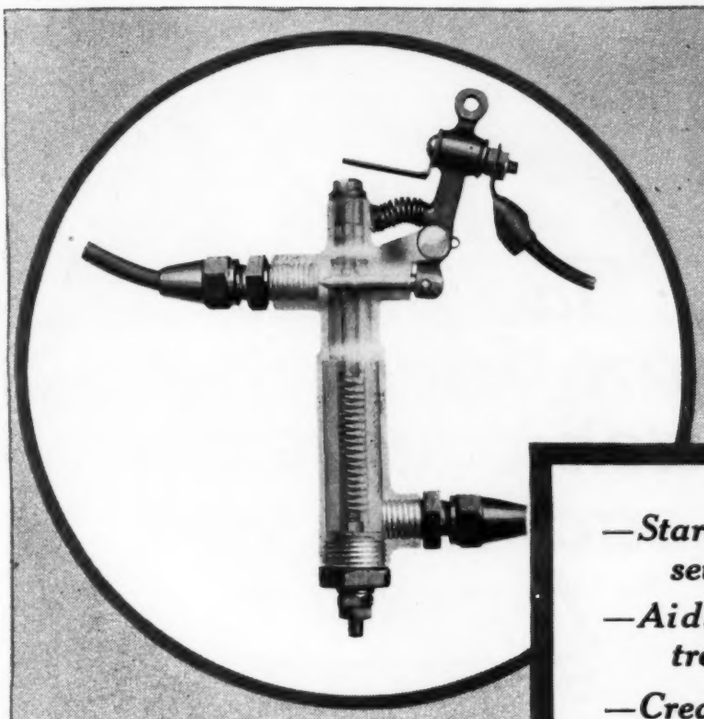
Our research organization will advise you regarding the possibilities of CONDENSITE in your plant. Send us a drawing of the part, together with a description of its functions and the conditions surrounding its use, i.e., the mechanical and electrical stresses to which it is subjected, the temperature if unusual, to what chemical action, if any, it is exposed and the approximate quantities required.

Molding of finished commutator made in one operation, thereby eliminating the multiplicity of operations in an assembled commutator in distinction to a molded commutator, resulting in great economy.

Condensite Company of America

Bloomfield, New Jersey

2017



—Starts the motor in less than seven seconds

—Aids in eliminating carbon trouble

—Creates higher motor efficiency

—Saves Battery—Saves gasoline

These are a few of the reasons why the Master Electrical Primer is as necessary as a self-starter on the car of today.

It has already proved a success on thousands of automobiles—it is a device which the motorist is going to look for on his new car.

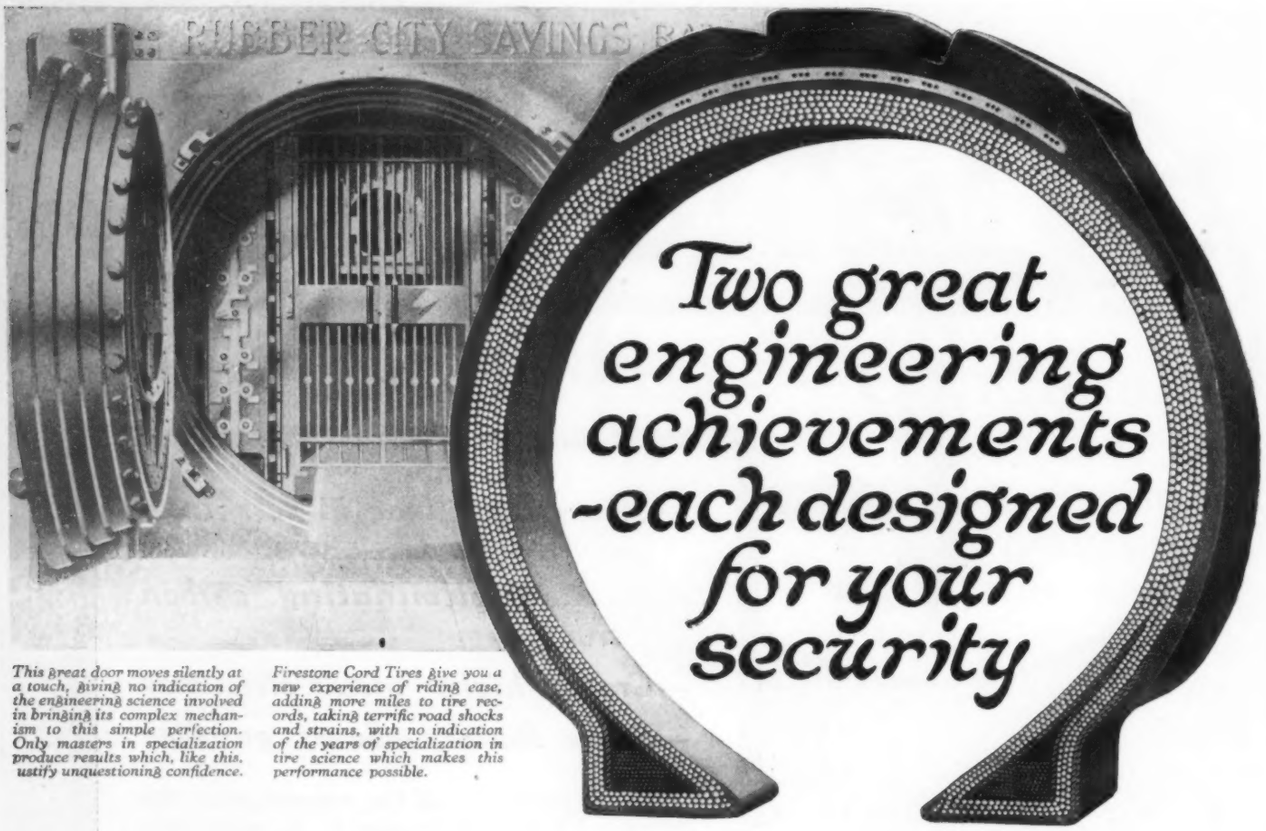
The Master Electrical Primer is now standard equipment on all 1918 Franklin Cars.

This is further proof of the value of the Master Electrical Primer in increasing motor efficiency and motor satisfaction.

Master Primer Company
34 East Larned Street
Detroit, Mich.

Master ELECTRICAL Primer

Instantaneous Starting in Zero Weather



This great door moves silently at a touch, giving no indication of the engineering science involved in bringing its complex mechanism to this simple perfection. Only masters in specialization produce results which, like this, justify unquestioning confidence.

Firestone Cord Tires give you a new experience of riding ease, adding more miles to tire records, taking terrific road shocks and strains, with no indication of the years of specialization in tire science which makes this performance possible.

THE illustration gives you only an idea what Firestone builders have done in cord tire betterments. You must see the section yourself, at your Firestone dealer's. Ride on Firestone Cord Tires. Then you will realize the values of more rubber in the tread, more depth of cushion layer, the Firestone reinforcement of the bead and sidewall.

You will get the new experience of Firestone resilience. You will see the gain in car power, because it is not wasted in tire resistance. You will prove this for yourself in easier starting, easier running and the longer coast. Never again will you be satisfied with ordinary cord construction.

And you will gain by your security in tire investment, your saving in tire expense, your satisfaction and comfort.

FIRESTONE TIRE AND RUBBER COMPANY

Firestone Park, Akron, Ohio — Branches and Dealers Everywhere

Firestone Cord Tires

The Great American Power

The Duesenberg Motor

DUESENBERG MOTORS CORPORATION, 120 Broadway, New York City

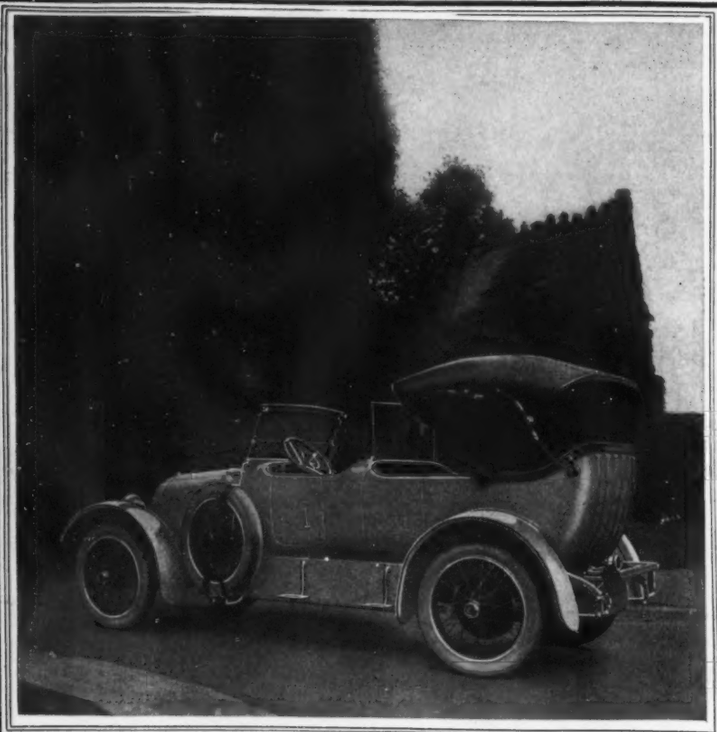
Contractors to the United States Government

The DANIELS

IS FACTORY-EQUIPPED WITH THE

Hartford
SWIVEL TYPE

SHOCK ABSORBER



On Many of America's Finest Cars

Makes Every Road a Boulevard

The Pioneer Shock Absorber

Here are four Daniels' reasons for equipping at the factory with Hartford Shock Absorbers:

They make steering easier on rough roads. Save wear and tear on power plant and chassis. Save tires, by holding wheels on the ground. Reduce side sway and prevent excessive spring action.

Tests will develop good reasons why you should equip **your** cars at the factory.

Why not make them? We will co-operate with you.

A Daniels Endorsement

CABLE ADDRESS
DANCAR READING

Daniels Motor Car Company

MANUFACTURERS OF
MOTOR VEHICLES
Reading, Penna., U. S. A.

Oct. 8, 1917.

Edward V. Hartford, Inc.,
#143 Morgan St.,
Jersey City, N. J.

Gentlemen:-

Our reasons for using Shock Absorbers as standard equipment on "DANIELS" cars, are:-

They make steering easier on rough roads.
Save wear and tear on powerplant and chassis.
Save tires, by holding the wheels on the ground.
Reduce side sway and prevent excessive spring action.

Our reason for using the Hartford Shock Absorber is, that of all the types tested, we found them to fulfil requirements the best.

Yours very truly,

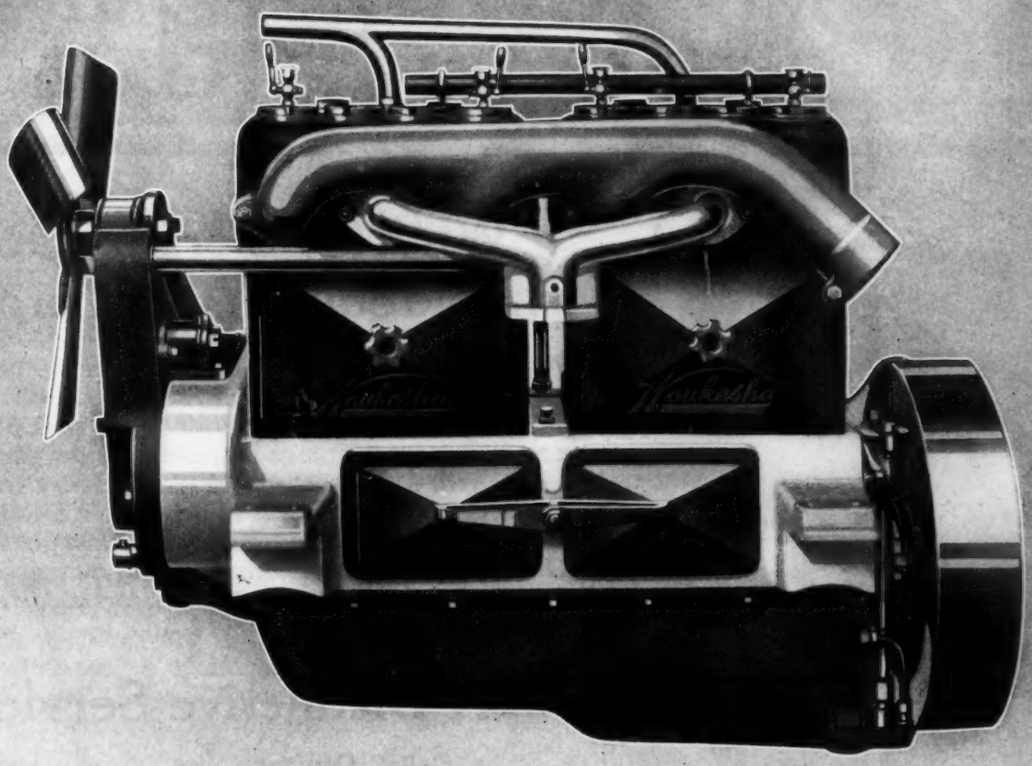
DANIELS MOTOR CAR COMPANY,

Chas. H. Tuft
Chief Engineer.

EDWARD V. HARTFORD, Inc.

240 MORGAN ST., JERSEY CITY, N. J.

Branches: NEW YORK, BOSTON, CHICAGO, KANSAS CITY. Distributors in Principal Cities.



By natural law, responsibilities gravitate to the man who can shoulder them. In a like manner the mechanical device which can best perform certain functions assumes the heaviest responsibilities in its particular sphere.

Waukesha
TRADE MARK

Four-Cylinder Motors for Trucks and Tractors

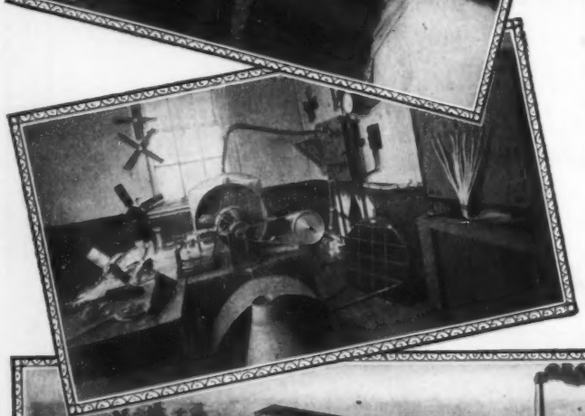
have attained a dominating position in the automotive industry because they possess that character which naturally invites the responsibilities incidental to arduous service.

"Demand a Waukesha Motor in the Truck or Tractor YOU Buy"

WAUKESHA MOTOR CO., Waukesha, Wis.

World's Largest Manufacturers of Truck and Tractor Motors Exclusively

OAKES



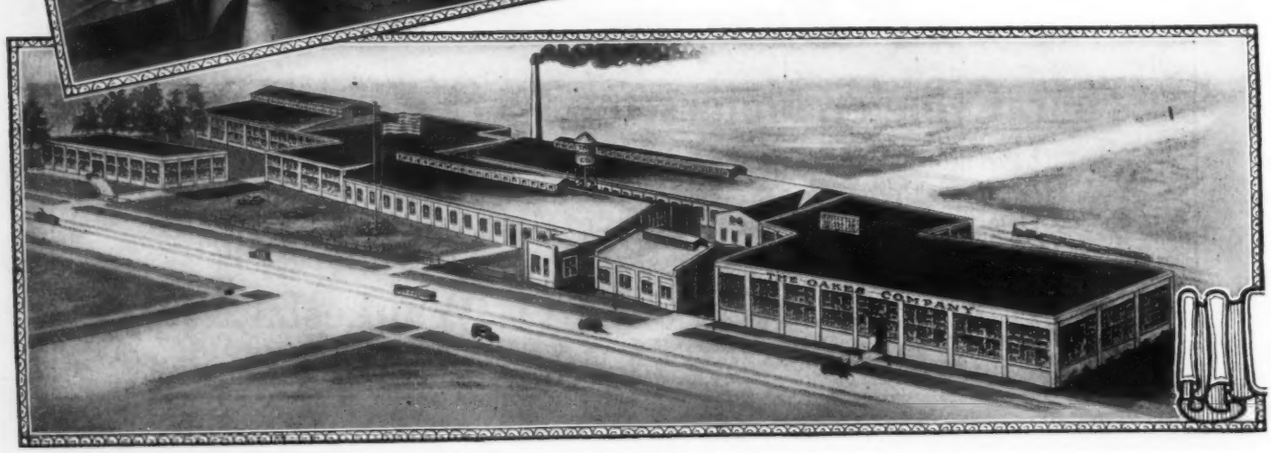
Why THIS organization should equip YOUR product

The Oakes Company has built up the largest organization in the world devoted exclusively to the making of radiator cooling fans. Its group of modern, fire-proof buildings represents a development of eight year's successful business. Every individual, every department, works tirelessly to maintain Oakes standards—those standards which have put the name Oakes high above all others in the matter of cooling fan efficiency. Over a million motors today are using Oakes Fans.

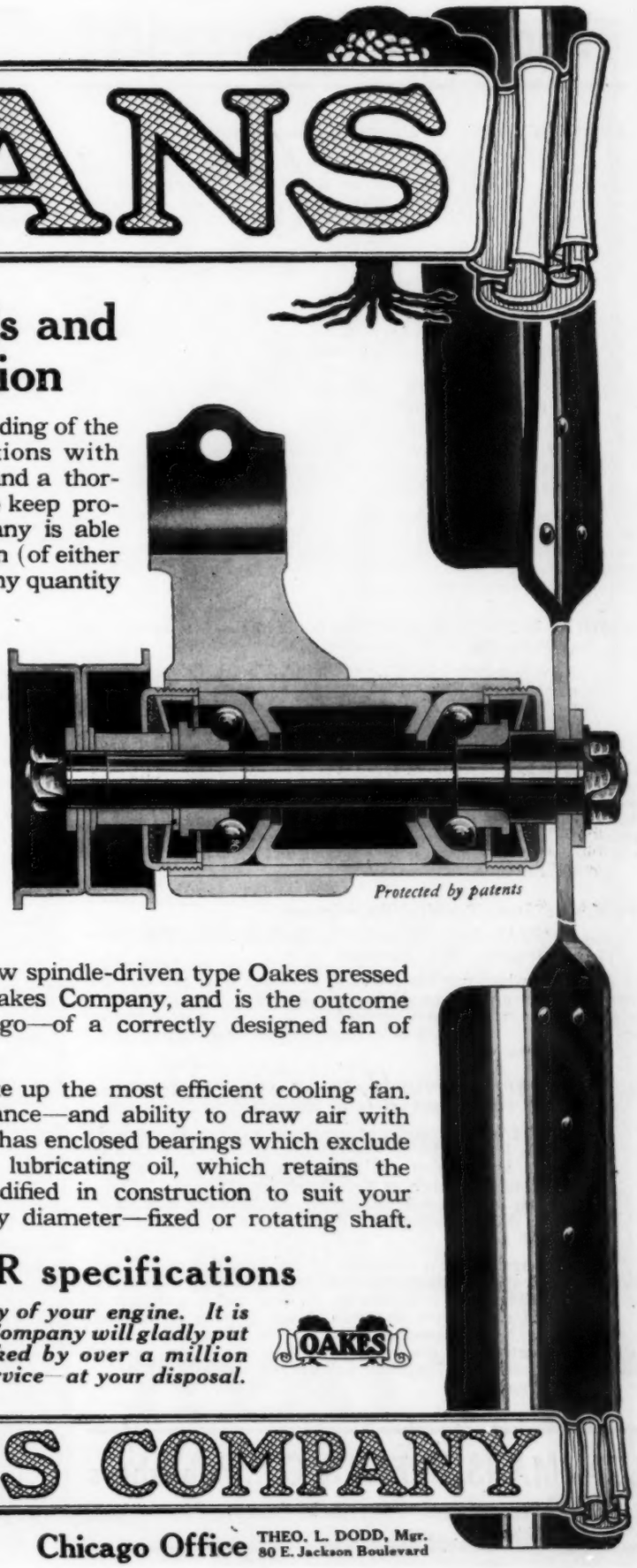
A Distinctive Service

The Oakes Company has its own engineering staff, which can render a valuable cooperative service to motor, tractor, truck and automobile makers. The company also has its own experimental laboratory—completely equipped with every modern device—answering such questions as H. P. consumption; end thrust; the capacity of fan in air velocity and volume; and the thermal efficiency of different radiators under variable conditions.

We are familiar with the fan requirements of practically every motor made. If we have no design suited especially to your needs we will soon have a special design ready for proof under actual conditions.



EFFICIENT COOLING FANS



A word about materials and facilities for production

The high and unquestioned financial standing of the Oakes Company—combined with connections with established and reliable sources of supply and a thoroughly modern factory—makes it possible to keep production at its maximum pitch. This company is able to produce radiator cooling fans of any design (of either fixed shaft or rotating shaft types), and in any quantity for trucks, tractors and automobiles.

The recent tractor shows and truck exhibits demonstrated the predominance of Oakes Fans. They are standard equipment on over 250 makes of tractors, trucks and automobiles. At the Kansas City Tractor Show, 80 per cent. of all tractors were equipped with Oakes Fans.

The Oakes Pressed Steel Fan Design

Illustrated is a sectional view of the new spindle-driven type Oakes pressed steel fan. It is the original design of the Oakes Company, and is the outcome of the company's conception—five years ago—of a correctly designed fan of pressed steel construction.

It embodies all the features which make up the most efficient cooling fan. It has sturdiness, lightness, quietness, balance—and ability to draw air with economical horse power consumption. It has enclosed bearings which exclude foreign matter; and a large reservoir for lubricating oil, which retains the lubricant for long periods. It can be modified in construction to suit your needs—flat or V belt—either rotation—any diameter—fixed or rotating shaft.

In making up YOUR specifications

OAKES

Consider the cooling efficiency of your engine. It is most important. The Oakes Company will gladly put its years of experience—backed by over a million motor fans in satisfactory service—at your disposal.

OAKES

THE OAKES COMPANY

INDIANAPOLIS, IND.

Chicago Office THEO. L. DODD, Mgr. 80 E. Jackson Boulevard

Books on Aeronautics

AERONAUTICS: In Theory and Experiment

By W. L. COWLEY, A.R.C. Sc., D. I. C., Whitworth Scholar; and H. LEVY, M.A., B.Sc., F.R.S.E., Carnegie Research Fellow, late 1851 Exhibitioner and Ferguson Scholar; Members of the Scientific Staff National Physical Laboratory. With Folding Plans, Half-tone Plates and 120 Diagrams. 8vo. $5.00 *net.*

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Fourth Avenue and Thirtieth Street, New York

BOOK REVIEWS—Concluded

energy requisite for flight; work required for various kinds of flight; foundations of flight technique; air pressure on a plane surface moved perpendicularly and uniformly; air pressure on a plane rotating surface; center of pressure on the wing during the downstroke; increasing air resistance by beating movements; economy in energy due to accelerated wing lift; expenditure of energy for flight without locomotion (hovering); resistance to oblique movement of a plane surface; energy required in forward flight with plane wings; superiority of natural wings over plane wing surfaces; determination of the wing shapes; most favorable wing section; advantages of curved wings over plane surfaces; difference between plane and curved surfaces as regards air resistance; influence of wing outlines; determination of the air pressure on birds' wing surfaces; air pressure on birds' wings determined on rotating surfaces; comparison of the direction of the air pressures.

PUTNAM'S AUTOMOBILE HANDBOOK. By H. Clifford Brokaw, principal, and Charles A. Starr, of the staff of the Automobile School of the West Side Y. M. C. A. of New York City. Published 1918 by G. P. Putnam's Sons, New York. Cloth, 5 by 7½ in., 348 pages, illustrated with photographs. Price $1.90.

This is primarily a non-technical book of information for the care and management of the automobile published perhaps more particularly for car owners. It is written in popular style, in fact, much of the material appeared previously in the automobile sections of certain New York newspapers. These newspaper accounts, here assembled under a single cover for the first time, have been rewritten and much new matter has been added.

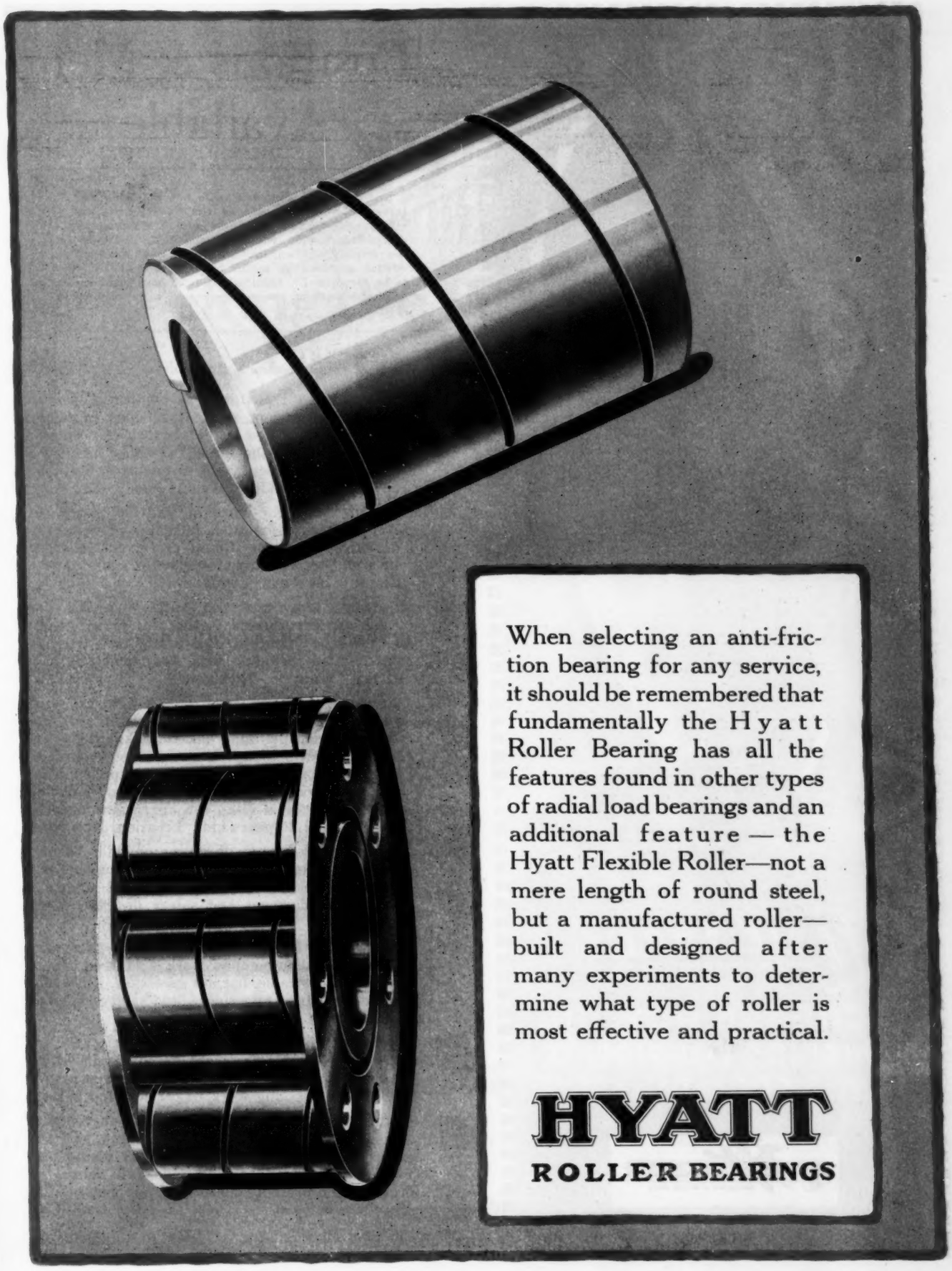
The contents of the book are based on the years of experience of the authors at the automobile school of the West Side Y. M. C. A., a pioneer automobile school, which has turned out during the past 14 years more than a thousand trained drivers annually.

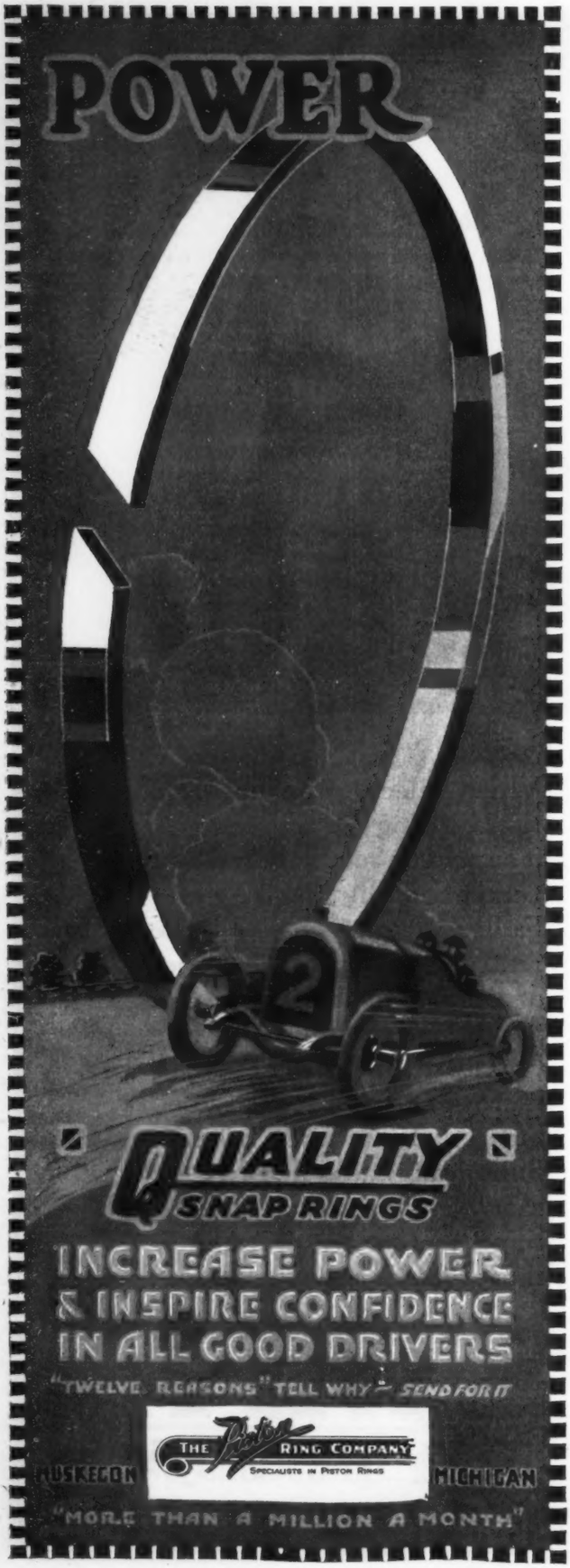
A comprehensive subject index is appended to the book, increasing its usefulness for ready reference purposes.

Among the subjects treated throughout the volume are the following: What to do on purchasing a car; some things to avoid; what an automobile is; what makes the engine go; equipment and accessories; where lubrication is neglected; the carbureter and its failings; getting the most out of a gallon of gasoline; care of the tires; skidding; brakes. The chapters on the electrical equipment are entitled, the elusive "juice"; putting the "kick" in the spark, and what's the matter with my battery?

Why gears strip; the muffler; bearings; driving the car; an auto furnace for winter; the cooling system in summer; overheating the engine in summer; some other hot-weather tips; guarding against fire; death in the gasoline; some things a tourist should know; causes of knocking; hunting trouble; women as drivers; miscellaneous rules—these are among the other subjects discussed throughout the volume. They indicate not only a diversity of subjects, but also a diversity of viewpoints.

The concluding chapter, "the golden rule of motoring," might well be called a preachment on the manners of the road. The authors present a severe arraignment of the manners of drivers toward pedestrians and other drivers, directing their observations more particularly to conditions in and about the metropolis.


When selecting an anti-friction bearing for any service, it should be remembered that fundamentally the Hyatt Roller Bearing has all the features found in other types of radial load bearings and an additional feature — the Hyatt Flexible Roller—not a mere length of round steel, but a manufactured roller—built and designed after many experiments to determine what type of roller is most effective and practical.
HYATT
ROLLER BEARINGS



Positions & Men Available

The following announcements are published for the information of members of the Society. No charge whatever is made for these announcements. Additional information will be supplied by the office of the Society. When items are prefixed by asterisk, written applications should be sent to S. A. E. office to be forwarded. Applications from non-members for positions must be properly endorsed by a member of the Society.

Positions Available

GOVERNMENT POSITIONS. A number of positions in the Government service are open in commissioned, enlisted and civilian capacities. This personnel work for the Society is being handled entirely by the Society of Automotive Engineers, 367 Munsey Building, Washington.

*491a. LAYOUT MAN for work on railway motor cars. American experienced in this line or in gasoline or kerosene engine design preferred. Give full information, including experience and salary expected. Location, Michigan.

*491b. DETAILER for work on railway motor cars. American experienced in this line or in gasoline or kerosene engine design preferred. Give full information including experience and salary expected. Location, Michigan.

*517. EXPERIMENTAL ENGINEER qualified to carry out technical research work, particularly on radiation. General scientific and electrical knowledge required. Previous experience as experimental engineer is unnecessary, providing applicant has had considerable research experience. Excellent opportunity for a clean-cut aggressive man between 25 and 30 years old. Location, New York.

*518. CHIEF INSPECTOR in large automobile factory. Must be thoroughly familiar with automobile and truck production. Give age, present and past place of employment and salary desired. Location, Detroit.

519. MECHANICAL DRAFTSMAN, with about two years' experience in automobile work preferred. Shop experience desirable, but not necessary. Give complete details as to experience, and salary expected, in first letter. Location, Indiana.

520. ENGINEER, high-grade man, to work in connection with engineering department, checking inspection, locating shop trouble, and working out improved methods of handling work. Location, Indiana.

521. MECHANICAL DRAFTSMAN wanted by engineering company. Man with at least five years all-around experience required (on steam power plants preferred). Applicant should give full details of previous and present connections, age, nationality, schooling, and salary expected. Location, Chicago.

(*Continued on page* 54)

DISTEEL WHEELS

DISTEEL WHEELS

Telling the World About Disteel Wheels

We prophesy—we can almost promise—that within sixty days Disteel Wheels will be universally established in the good opinion and the logical judgment of the quality-car owners of this country.

It is now scarcely seven months since Disteel Wheels were first introduced—in the motor car journals. Yet the acceptance of and demand for Disteel Wheels at the hands of motor car manufacturers and dealers have been amazing. We question whether any motor car accessory has ever met with a response so instantaneous and so nearly unanimous.

Now we are carrying the message of Disteel Wheels, the Beauty and Safety and Economy and Comfort of Disteel Wheels, straight to the discriminating motor car owners of the country. We are talking Disteel Wheels and showing Disteel Wheels to the largest and most representative audience in the world.

We are doing this by means of a Campaign of National Advertising. We are using only the largest and most influential mediums. And we are using full-page space. For example, look for the Disteel Wheel announcements starting in The Saturday Evening Post of April 27 and the Literary Digest of April 20.

If you are handling a quality-car, you can readily grasp what this national advertising of Disteel Wheels will do for better-wheels in your own territory. And remember—Disteel Wheels are sold only through the motor car dealer.

DETROIT PRESSED STEEL COMPANY

1804 Mt. Elliott Ave. Detroit, U.S.A.

New York Office,
1846 Broadway

Boston Office,
925 Boylston St.

DPS

USED ON HIGH-CLASS MOTOR VEHICLES

as the one absolutely satisfactory gasoline carrying receptacle.

Only the finest steel is used in making "Jasco" tanks. They are seamless drawn, tinned and tested—will not leak under the severest strain of the roughest service.

Send for detailed literature.

JANNEY, STEINMETZ & CO.
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The Mark of Quality

TOLEDO STEEL CASTINGS

DELIVERIES? Ask our Customer
QUALITY? Ask his Engineer
PRICES? Ask US

WE ARE SPECIALISTS, so

Put your problems up to our engineers and metallurgists

THE TOLEDO STEEL CASTING CO.
TOLEDO, OHIO, U. S. A.

POSITIONS & MEN AVAILABLE *Cont.*

Positions Available (Continued)

*522a. DRAFTSMAN, experienced in transmission and rear-axle truck work. Location, East.

*522b. DETAILERS, several men for truck work. Location, East.

*522c. TRACERS, several men for truck work. Location, East.

*523. PYROMETER MAN, experienced in installation and maintenance of pyrometer equipment. Location, Cleveland.

524. CHIEF INSPECTOR for high-grade commercial engine manufacturing company. Man with many years of experience and good record; must have good executive and organizing ability, and be a thorough mechanic. Location, Ohio.

525. METALLURGIST, excellent position in one of the largest aluminum foundries in the East. Must be in good standing, and experienced in handling aluminum from both the material and foundry standpoint. Excellent opportunity for the right man. Location, New Jersey.

526. SALESMEN for selling trucks and farm tractors to dealers in Eastern territory.

527. DRAFTSMEN, three or four good layout men and detailers for high-class tractor work. Men understanding tool designing preferred. State salary expected and give references. Location, temporarily New York City.

530. MECHANICAL, CHEMICAL, TECHNICAL GRADUATE with four or five years' experience in light machine shop practice or bearing metal foundry work. For a man who has executive ability and ability to handle men, this offers exceptional opportunities to work up a responsible position in the operating and production field. State age, whether married or single, education, previous experience, salary expected. Give references. Location, Illinois.

531. ASSISTANT ENGINEER and mechanic. A man with some automobile experience for a testing laboratory. Location, New York.

*532. TOOL ROOM FOREMAN, man with broad experience and some executive ability, wanted by truck and tractor engine manufacturer. State experience in detail, give references, and state salary expected. Location, Northern Ohio.

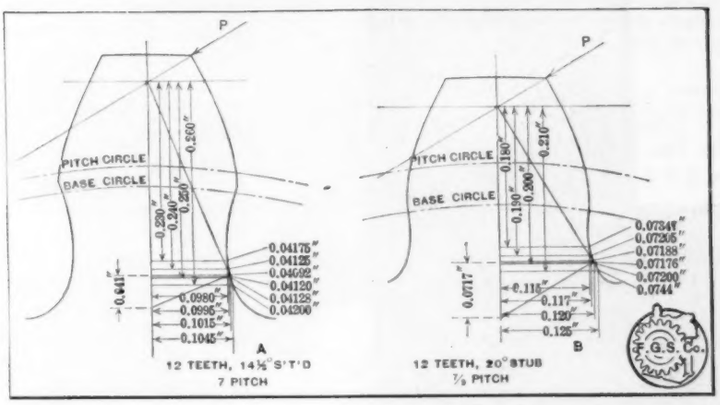
533. DRAFTSMAN with a few years' experience in shop and drawing room, on medium or heavy machinery. Location, New York.

534. AUTOMOBILE ENGINEER who has had actual experience in passenger-car work, and can also help develop a light tractor. Location, South Carolina.

535. ENGINE INSPECTORS. The Bureau of Aircraft Production is in urgent need of several qualified inspectors for aeronautical engines, magnetos, and spark-plugs. They will become civilian members of the Bureau and will serve their country in a particularly effective way. Men with long experience in the manufacture of engines, magnetos, and spark-plugs, especially those familiar with micrometric inspection and with sub and final assembly, desired. The positions will carry salaries from $1,500 to $1,800 per annum with periodic

(*Continued on page* 56)

Are These Two Gear Teeth of the Same Strength?



Obviously they are not. The one shown at A is not only narrower at the base, but is considerably longer, and hence the leverage exerted on the base of the tooth is greater.

In fact, by accurate calculation it is found that the tooth at B is 75 per cent stronger than the one at A.

Now, what is the chief reason why the tooth shown at B is so much stronger than the one shown at A?

This is quite a long story, but engineers who are really interested in knowing the reason will appreciate receiving a copy of our booklet entitled "The Stub Tooth Gear."

Kindly state the position you occupy and the firm by whom you are employed when requesting a copy of this booklet.

The Fellows Gear Shaper Company

Springfield, Vermont, U. S. A.

For
TRACTOR SERVICE
G & O
Radiators
fill the demand for an engine cooling unit of proven reliability; the result of correct design, pains taking attention to the details of manufacture and the use of the very best materials.
Our Engineering Department is at your service
The G & O Mfg. Co.
New Haven, Conn., U. S. A.
G&O
Radiators

VICTORY FIRST

Our plant is **first** subject to Government demands—but while we are doing Government work, we are still able to take care of those who are looking to us for their requirements of

CUSHION SEAT SPRINGS
AND BACK SPRINGS

JACKSON CUSHION SPRING CO.
JACKSON, MICHIGAN

POSITIONS & MEN AVAILABLE *Cont.*

Positions Available (Concluded)

increases, where deserved. Most of the positions located near New York. Apply in person to the chief, Engine Section, Bureau of Aircraft Production, 6th Floor, Grand Central Palace Building, New York City.

Men Available

0484. EXECUTIVE ENGINEER, university graduate, 10 years' experience in designing and manufacturing engines, pleasure and commercial vehicles. Capable of developing new ideas and taking charge of experimental and research work.

0485. ENGINEER, technical education, experienced in design and layout of trucks and tractors and general drafting-room practice, desires position in tractor work, with opportunity to get into the service or sales end. Experience in service work. Salary dependent on opportunity afforded.

*0486. ENGINEER AND EXECUTIVE capable of taking charge of engineering or experimental department. Nine years' experience in design and construction of passenger and commercial cars—internal combustion engines for aeronautical, automobile, truck, tractor and marine work. Have conducted extensive research and development on internal combustion engines, gasoline and kerosene carburetors, and have specialized on engine design. Competent in perfecting new ideas, and supervising men in design and construction. Thoroughly acquainted with modern manufacturing methods and systems.

0487. EXECUTIVE OR SALES MANAGER. Has several years' experience as manager in New York City, representing a tire factory of unquestioned standing. Would consider position with growing tire company.

0488. ENGINEER, university graduate in mechanical engineering with six years' practical experience who has specialized on both water-cooled and air-cooled engine design. Desires position as assistant chief engineer, or designing engineer with company manufacturing engines or automobiles.

*0489. SERVICE MANAGER OR MECHANICAL SUPERINTENDENT; fifteen years' automobile experience. Has a thorough knowledge of the best manufacturing, operating and repair methods. Thoroughly competent in handling a large number of vehicles; can handle men and is a good organizer. Executive position held for the last ten years, now managing mechanical end of a large transportation company. Desires to make change. Best of references.

0490. CHIEF ENGINEER. An executive who can organize rapidly and pave the way for increased production. A driver rather than a diplomat. Now helping in winning the war, but must have permanent position. Age 31, married. Salary, $4,200.

0491. AERONAUTICAL ENGINEER, graduate, 32 years old, has had eight years' professional experience, including toolmaking and designing.

0493. SALESMAN AND EXECUTIVE, ten years manufacturers and retail selling and advertising experience

(*Continued on page* 58)

BROWN-LIPE-CHAPIN
DIFFERENTIALS

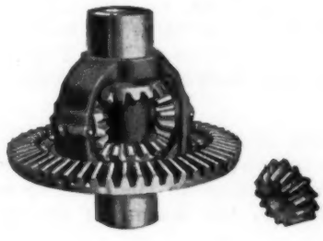
EVEN in these days of increasing demand on steel production we continue to be exacting about quality.

A steel maker not long ago told us that the practical tests we use are too drastic and that our requirements are too severe.

But all steel furnished us for our products must "measure up" under our drastic and severe requirements.

Our engineering department will assist you in solving your differential problems. Write us today.

Bevel Type Differential used by Dort Motor Car Co., Inc. Axles built by Walker Weiss Axle Company, Flint, Mich.



BROWN-LIPE-CHAPIN CO.
DIFFERENTIALS
Syracuse N. Y.

Representatives:

San Francisco: A. H. Coates, 41 Speare St. Foreign Agent: Benjamin Whittaker, 2 Norfolk St., Strand, London, W. C.

Sleeveless, Valveless Engine Design For Sale

A large manufacturing company which built automobiles before the war offers for sale a sleeveless, valveless four-stroke-cycle engine, thoroughly protected by fundamental patents. The experimental engine has driven a 5000-pound car nearly 60,000 miles, proving its reliability. The engine was developed for automobiles and has many features superior to the poppet or Knight types. Cheap to build. Very efficient. Replies should be addressed to Engineer, Society of Automotive Engineers, 29 West 39th Street, New York City.

"A Sure Start Assured"

is simply another way of saying that a car is equipped with

THE "Exide" BATTERY

There's an "Exide" Battery for every car and an "Exide" Service station in Principal Cities and Towns.

THE ELECTRIC STORAGE BATTERY CO

The oldest and largest manufacturer of Storage Batteries in the Country

1888 PHILADELPHIA, PA. 1918

New York, Boston, Washington, Minneapolis, Denver, Detroit, San Francisco, Kansas City, Chicago, Cleveland, Atlanta, Pittsburgh, St. Louis Rochester, Toronto

POSITIONS & MEN AVAILABLE *Cont.*

Men Available (Continued)

in accessory lines, principally ignition and starting and lighting. Also thorough mechanical knowledge. Good correspondent. Can manage sales or service department. Highest references.

*0494. PATENT ATTORNEY, specialist on motor vehicles and related subjects, adequate training and experience; especially able to deal with the technical aspects of patent work. Will consider employment by automobile, engine, or parts company as special patent counsel, for whole or stated part time.

0495. GRADUATE, mechanical engineering, of Drexel Institute, Philadelphia, and at present senior at Massachusetts Institute of Technology, wishes work on automatic machine design problems or on government work having to do with gasoline engines. Prefers location near New York City or Philadelphia. Age 23; exempt from draft; married.

0496. ENGINE SPECIALIST and EFFICIENCY EXPERT familiar with airplane engines, truck, tractor and car design. Over fifteen years' experience, wants connection as designer or consulting engineer.

0497. SALESMAN, sixteen years' experience in automobile business, last six years in selling steel products to all classes of manufacturers. Chicago territory preferred. Salary and bonus preferred.

*0498. AUTOMOTIVE ENGINEER and executive. Age 38. Training: technical college and practical shop work. Has originality and initiative and 20 years' experience in mechanical, electrical and automotive engineering, designing, developing problems and improvements, researches, etc. Last six years as general manager and consulting engineer. Will give part time or entire time.

0499. MECHANICAL ENGINEER—seven years' experience in designing and experimental work on automobiles, specializing on carburetion. Desires a position in the engineering department of automobile or tractor manufacturer or company making automotive parts. Available, August 1.

0500. SALESMAN, expert on carbureter selling and engine testing, demonstrating. College education. Available at once.

0501. TECHNICAL GRADUATE, age 38, member S. A. E. and Junior Member A. S. M. E. since 1906, wants position. Experienced in shop office and sales methods, gained as chief inspector of airplane engine manufacture and test, in the engineering department of shipyards, as assistant superintendent of manufacturing plant and as sales manager of a machinery house in New York. Location desired, Middle West or Pacific Coast. Available at once.

*0502. CHIEF ENGINEER, young energetic automotive engineer who is accustomed to designing for large production—either complete machines or units—especially expert in the design of water-cooled engines.

(*Concluded on page* 60)

Automotive engineers are unanimous on this point

Regardless of cost—unfailing quality is absolutely necessary in a magneto.

Some few customers would tempt us to compromise our engineering ideals in order to meet price competition.

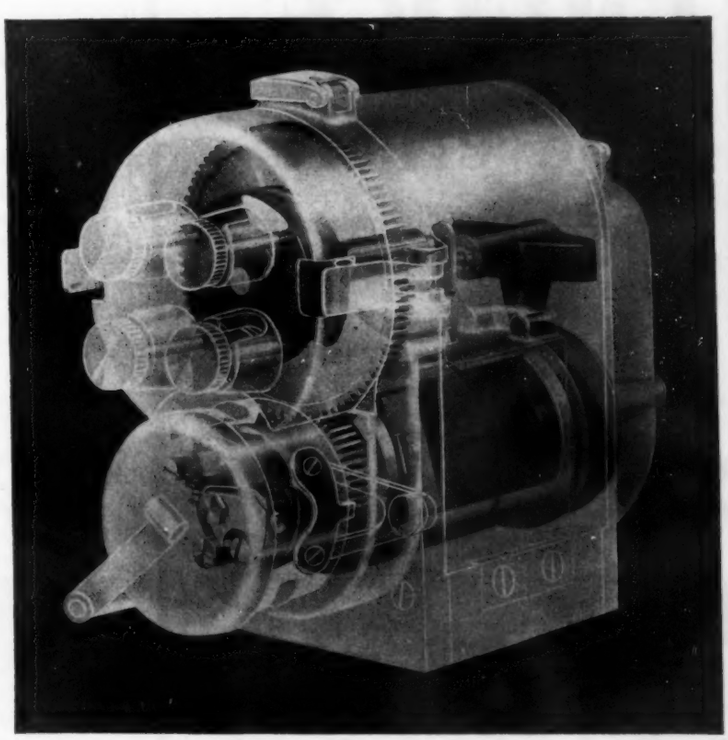
But we hold steadfast to the Berling policy of "Worth more—does more."

Even though Berling Magnetos have to cost somewhat more, we will adhere to the viewpoint of the automotive engineer: "Quality first."

Berling Magneto

WORTH MORE *DOES MORE*

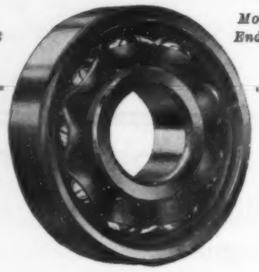
ERICSSON MFG. CO.
Buffalo, N. Y.



P. S. Why not write us your own opinion on this question?

Definitely Located. Three Area-Contact

More than Three-fold End-Thrust Capacity



Quality Superb

Safety Absolute

Schatz "Universal Annular Ball Bearing

The Development of Years

The end thrust supremacy of the "Universal" is the climax of our 20 years of ball bearing manufacture.

Three years were devoted to experimentation to perfect the design and develop the bearing to high efficiency before offering it to the trade.

Nothing has been accidental in the development of the unique features that have made our

"Universal" an International Triumph

Send for Catalog and Data Sheets

THE FEDERAL BEARINGS COMPANY, Inc.

30 William Street, Poughkeepsie, N. Y.

Great Britain: 37 Sheen Rd., Richmond, London

PIERCE Governors

STANDARD Equipment on EIGHTY-TWO Makes of Trucks.

If Pierce Governors did no more than keep motor truck drivers from exceeding the speed limit, they would be worth ten times what they cost.

But that is not the reason why eighty-two truck manufacturers adopted these governors as standard equipment. They don't care a rap how many collisions the driver has, or how many damage suits the owner pays.

Pierce Governors were chosen because they alone positively prevent rapid wear and prohibitive upkeep cost—inevitable results of excessive speeds.

Don't accept a substitute.

The Pierce Governor Company

World's Largest Governor Builders

ANDERSON, INDIANA

POSITIONS & MEN AVAILABLE *Cont.*

Men Available (Concluded)

0503. ENGINEER, university graduate with two years' experience in designing and developing heavy-duty motor trucks. Capable of taking charge of experimental and research work. Desire connection with growing concern as assistant chief or research engineer. Prefer central location.

0504. ADVERTISING EXECUTIVE with ten years' automobile experience. A member of the Society, seeks permanent connection with sound concern. Thorough knowledge of motor car, truck, tractor and airplane advertising. Married.

0505. EXECUTIVE SALES ENGINEER. Young man with engineering, manufacturing and sales experience. Understands modern production methods and has practical experience in advertising. Technical graduate. Is capable of acting as connecting link between manufacturing and marketing. Possesses ability as organizer and has made a special study of industrial efficiency. Desires executive position requiring versatile ability. Preferably with tractor or truck manufacturer. Exempt from draft. Highest references.

0506. DESIGNING OR PRODUCTION ENGINEER—graduate mechanical engineer—twelve years' experience. Especially competent to take charge of design and development or production of motor trucks or tractors.

0507. EXECUTIVE ENGINEER—twenty-four years' progressive manufacturing experience. Expert in development of original ideas through design, experimental and manufacturing phases. Aggressive, clean-cut personality. Age 38. Work on essentials preferred.

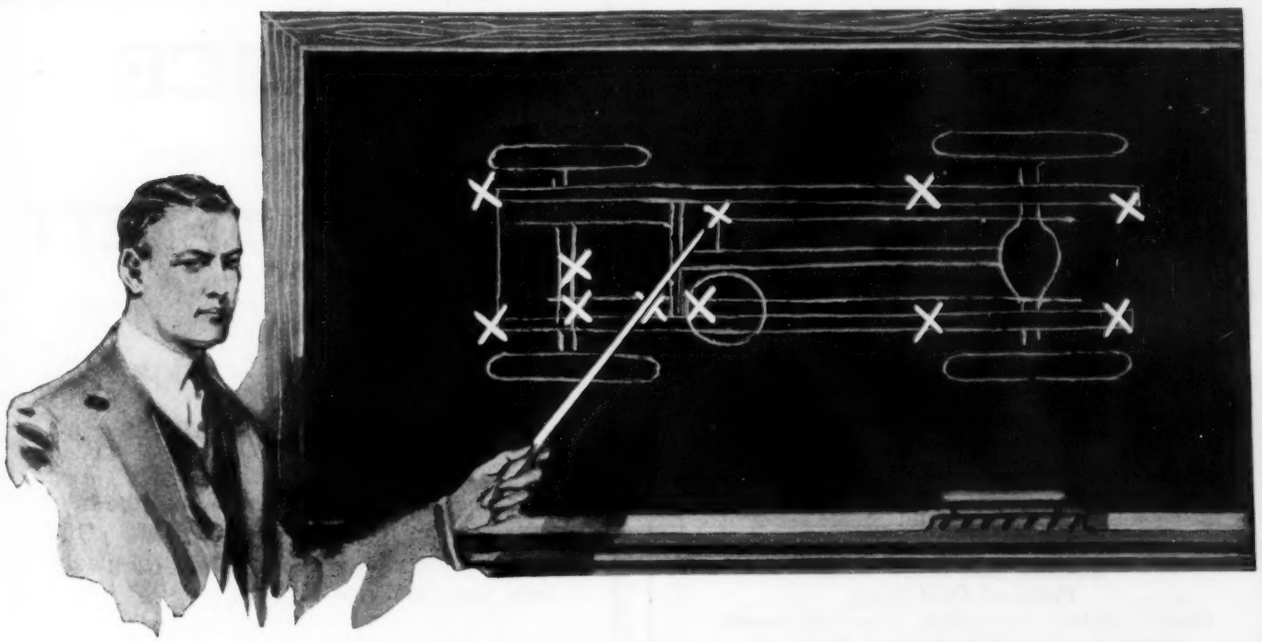
0508. SALES MANAGER, broad sales and mechanical experience, now employed in like capacity with largest tire and accessories concern in Southwest. Formerly district manager for prominent tire company.

0509. EXECUTIVE with broad experience in organization and production work, based on a thorough and practical knowledge of modern manufacturing processes. Age, 35; married. Available on short notice. Prefer Middle West. Nothing but high-grade position, paying fair salary, considered.

0510. SALESMAN and director of sales. Ten years' experience in selling automobile accessories, wholesale automobiles and trucks, prefers location near Indianapolis. Age 34. Best of references.

*0511. MECHANICAL ENGINEER, technical graduate, ten years' experience as chief engineer and factory manager in truck, farm tractor and passenger car manufacturing. At present employed as chief engineer and production manager with prominent company in the passenger car line as well as doing considerable government work. Would like to change back to truck or tractor line.

0512. RESEARCH AND EXPERIMENTAL ENGINEER specializing on internal combustion engines of all sorts, wishes to become interested in and connected with company manufacturing such machines. About ten thousand dollars to invest.



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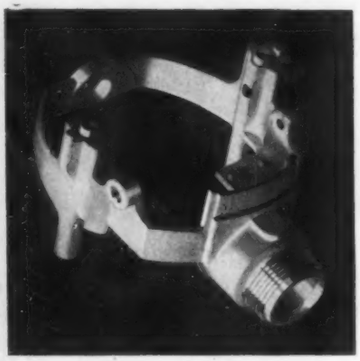

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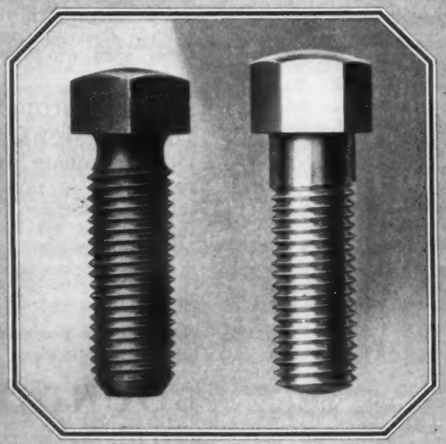

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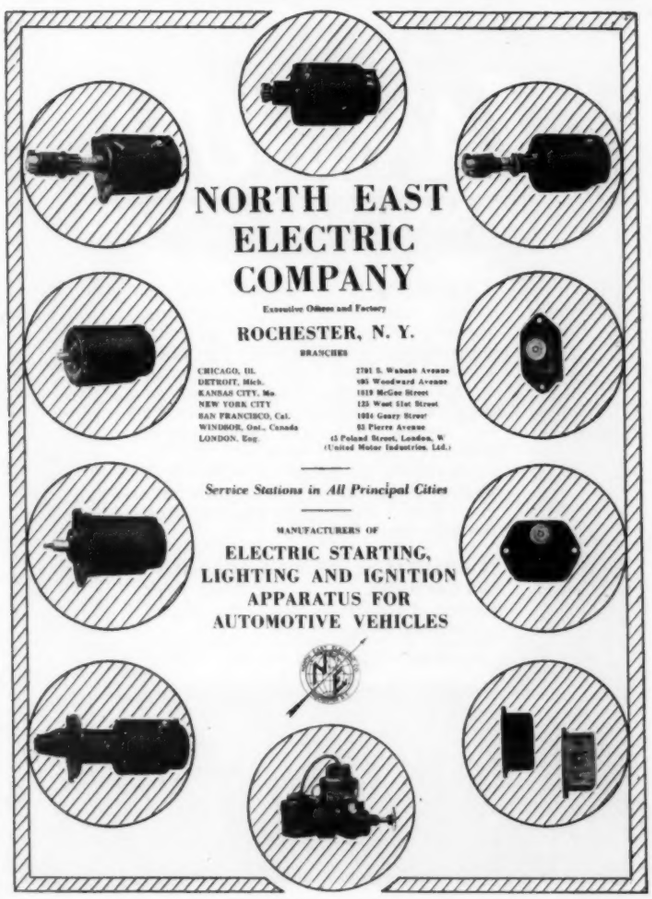

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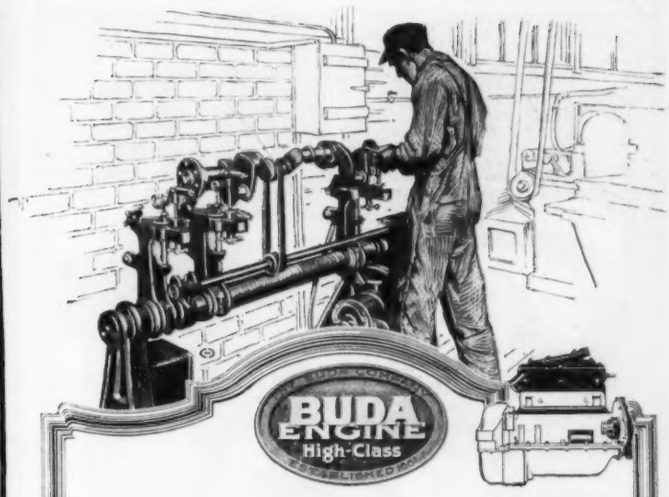

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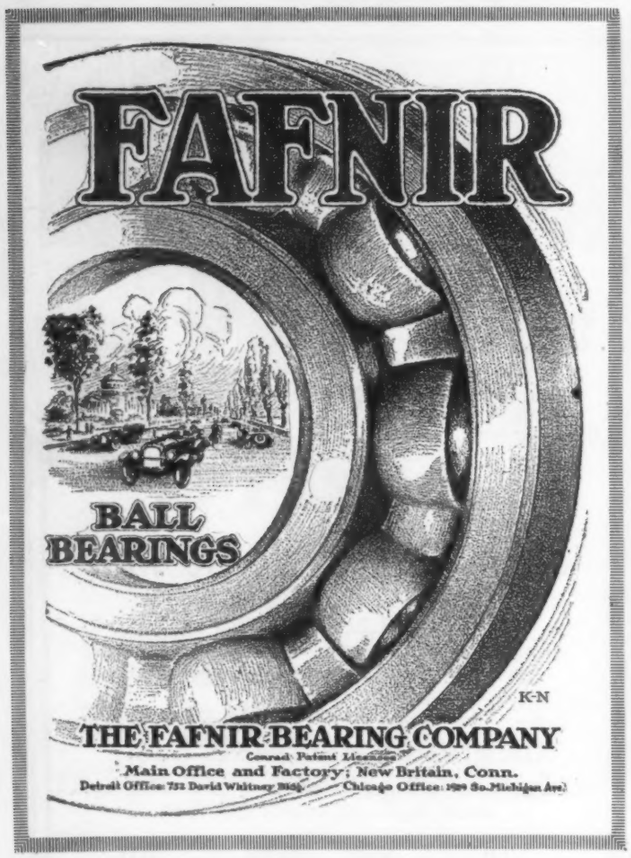
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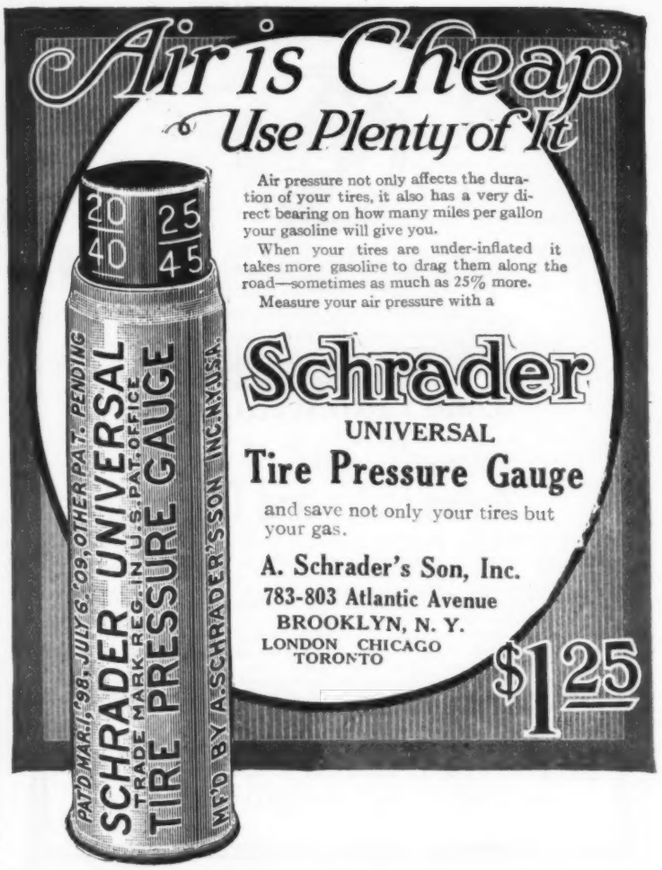
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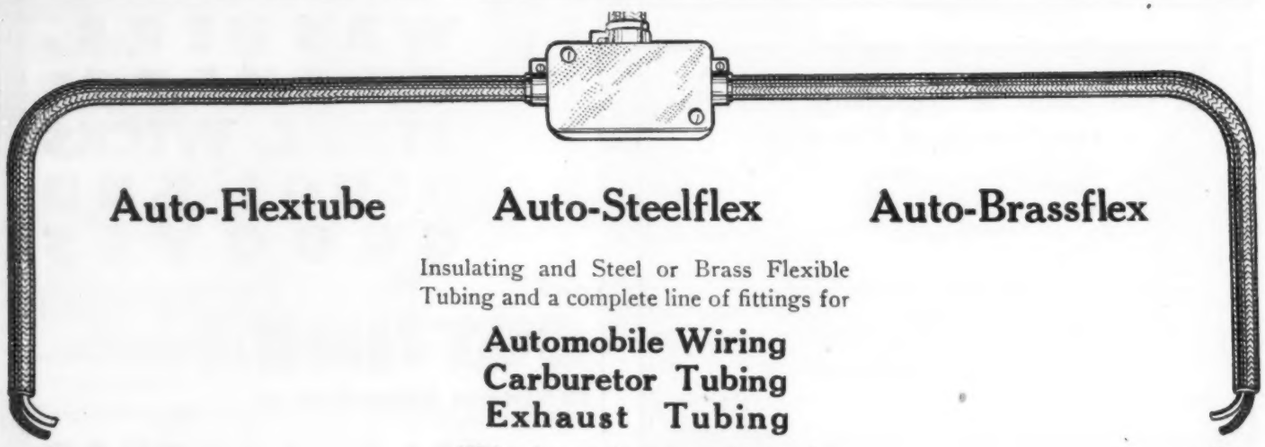

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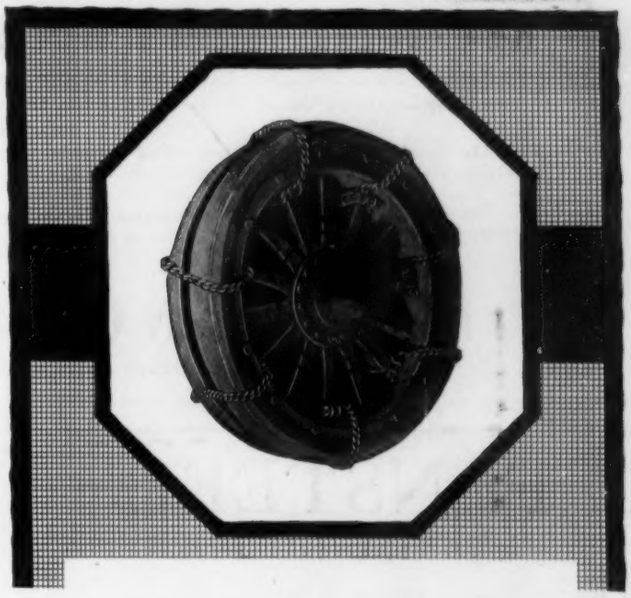

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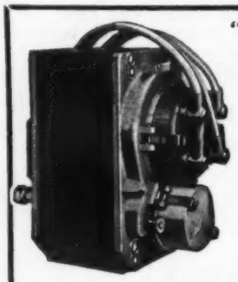

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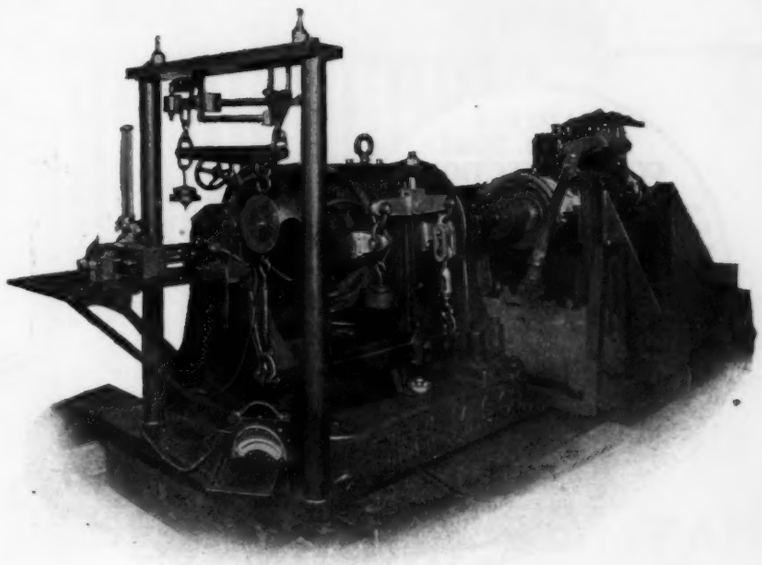

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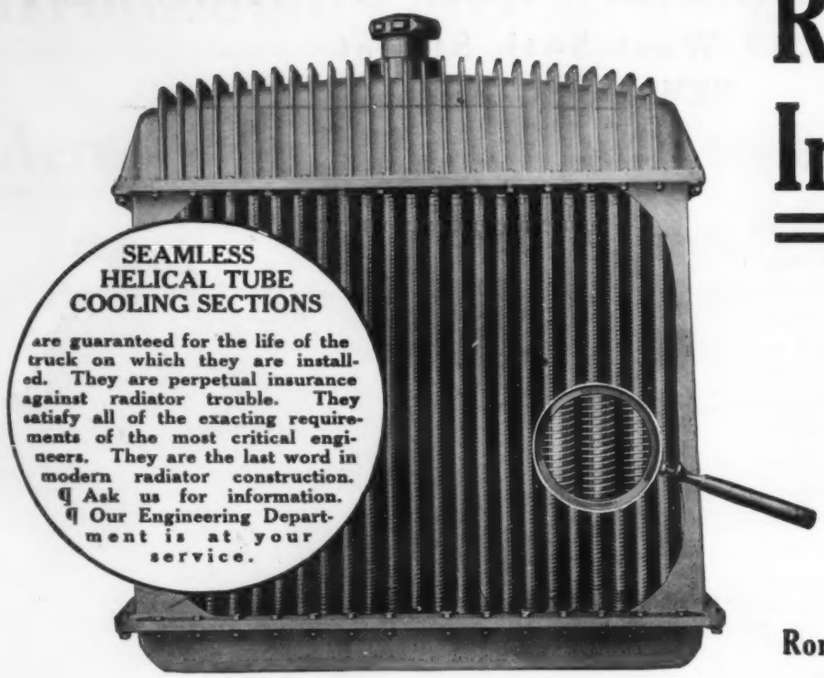
PARISH MANUFACTURING COMPANY

DETROIT, MICH. **READING, PA.**


SEAMLESS
HELICAL TUBE
COOLING SECTIONS
are guaranteed for the life of the truck on which they are installed. They are perpetual insurance against radiator trouble. They satisfy all of the exacting requirements of the most critical engineers. They are the last word in modern radiator construction.
¶ Ask us for information.
¶ Our Engineering Department is at your service.

Radiator Insurance

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Sole Manufacturers

Rome-Turney Radiator Co.
Rome, N. Y., U. S. A.

UNION DRAWN STEEL CO.

General Offices: Beaver Falls, Pa. Works: Beaver Falls, Pa., and Gary, Ind.

COLD DRAWN OR TURNED AND POLISHED

- Shafting
- Screw Steel — BESSEMER, OPEN HEARTH
- Alloy Steels (Heat Treated or not) — NICKEL—1% AND 3½%, NICKEL CHROMIUM, CHROMIUM, CHROMIUM—VANADIUM, ETC.
- Axles, Piston Rods
- Special Shapes
- Special Case-Hardening Steels

Cold Finished Bessemer, Open Hearth, Crucible and Electric Furnace Steels

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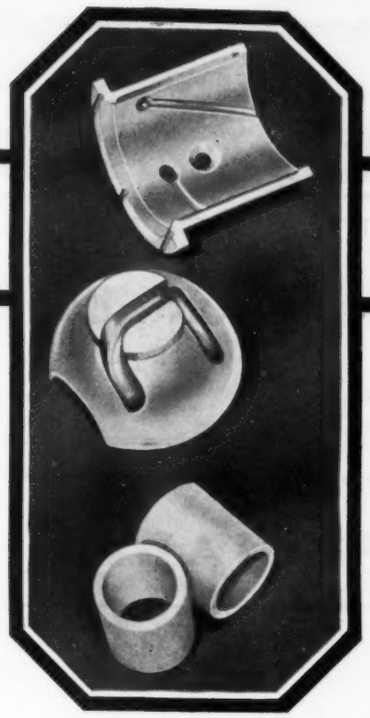

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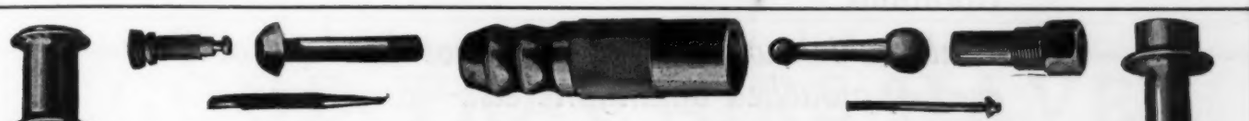
DIE-CASTINGS

Dependability

Franklin Die-Castings were the first to be applied to the Automobile industry.
And ever since they have maintained an unbroken record for satisfactory service.
To-day, whether for automobile work or munitions, the country's leading manufacturers are glad to depend on Franklin Die-Castings for Accuracy, Strength, Finish and Deliveries.

Send for Booklet "A",—it contains interesting information; or request our representative to call.

FRANKLIN MANUFACTURING COMPANY
755 GIFFORD STREET, SYRACUSE, NEW YORK



COLUMBIA STEEL & SHAFTING CO.

MILLS
AND GENERAL OFFICES
PITTSBURG, PA.

EASTERN SALES DEPARTMENT
AND WAREHOUSE
BOSTON, MASS.

MANUFACTURERS OF
COLD DRAWN AND DIE ROLLED ROUNDS, HEXAGONS, SQUARES, FLATS, SPECIAL SHAPES, SCREW STOCK, AXLE AND ALLOY STEELS
COLUMBIA TURNED AND POLISHED STEEL SHAFTING
THE LARGEST AND MOST COMPLETE STOCK OF COLD FINISHED STEELS
MONTHLY STOCK LIST ISSUED

SCREW STOCK

After many years of careful experiment, we have adopted and now use for free cutting screw stock a specially selected analysis steel, which owing to its absolute free cutting and threading properties has proved among the authoritative consuming trade to be admirably suited and best adapted for use at high speed, with maximum production of parts, in such as the automatic and hand screw machine and turret lathe operations.

Complete equipment with every facility to offer the very best products, provides, and extreme care with close attention to the requirements of our trade insures, such uniformity of structure and accuracy sufficient to substantiate the claim of superiority (based on expression of trade opinion) in "Columbia" free cutting screw steel.

SALES OFFICES: CHICAGO CLEVELAND DETROIT PHILADELPHIA

DROP FORGINGS

THE WHITMAN & BARNES MANUFACTURING CO.

ESTABLISHED 64 YEARS

1000 WEST 120th STREET, CHICAGO, ILL.

VIBRATIONS OUR SPECIALTY

Here is what we do:

We manufacture balancing apparatus

We balance crankshafts, flywheels, etc.

We investigate and report on all problems involving vibrations.

The results which we guarantee cannot be duplicated or even approached by anyone else—anywhere.

VIBRATION SPECIALTY CO. Harrison Building, Philadelphia

N. W. Akimoff, Engr. and Mgr. *Positively not connected with any other concern*

His initials MA our trade mark

Manufacturers of Balancing Machinery Static and Dynamic
(Akimoff LATEST designs)

Laboratory of Practical Balancing
(Akimoff LATEST methods)

Misinformation Worse Than None

The Ammeter on the dash or cowl has only one purpose—to give *accurate* information *all the time* regarding the condition of your electrical equipment.

Weston

Model 301 Ammeter

is built by the Company whose leadership in the manufacture of electrical indicating instruments is recognized the world over. Without qualification, it is superior in accuracy, durability, reliability, to any other Dashboard Ammeter. Better be sure yours is a Weston Ammeter. *Write for full information.*

Weston Electrical Instrument Co.
38 Weston Ave., Newark, N. J.
23 *Branch Offices in the Larger Cities*

RECRUITS WANTED

for Army of War Savers

SEE PAGE 30

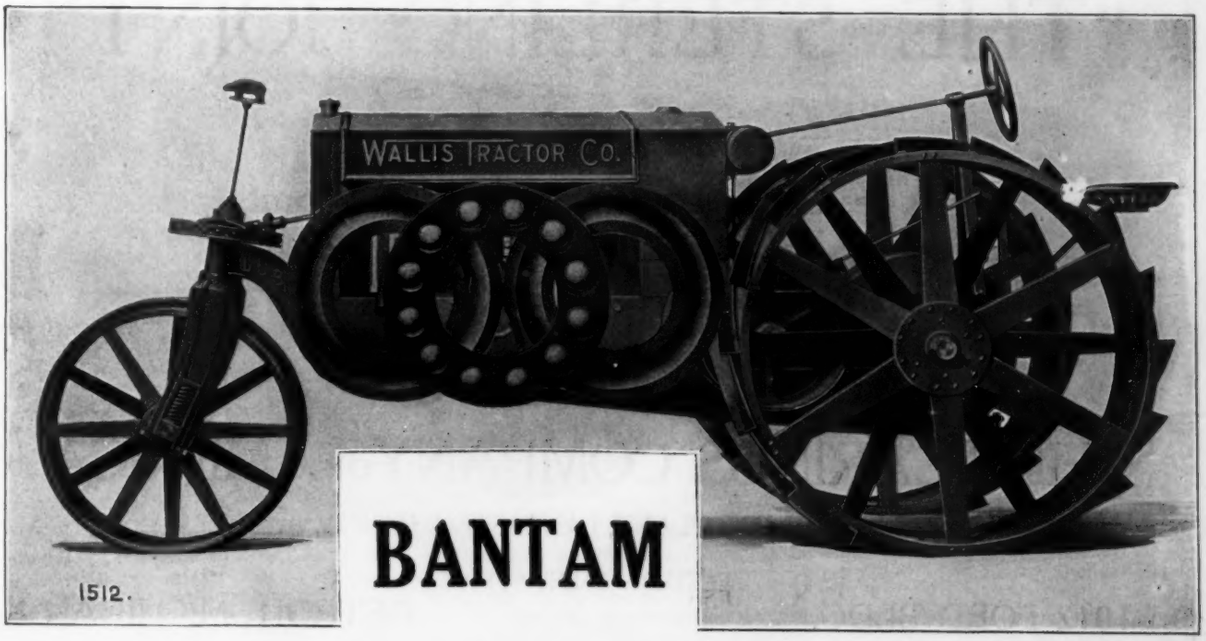
SMITH PRESSED STEEL FRAMES

They Set the Standards for the World

A. O. Smith Corporation

MILWAUKEE, WIS.

GOOD TRACTORS HAVE



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BALL THRUST BEARINGS

BANTAM CONN.

Spicer
Universal Joints

Universally Accepted as the Most Dependable Flexible Connection Known to Motor Car Practice

Grease-Tight Dust-Proof

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"THE STERLING JOINT"

A tested and proven Universal Joint, typical of its name, for motor trucks and passenger automobiles.

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STERLING PLANT, LANCASTER, PENNA.

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HY-TEN STEEL

HIGH GRADE STEELS FOR EVERY PURPOSE

STRENGTH
TOUGHNESS

UNIFORMITY
SERVICE

Neither a bow knot nor a doughnut but a piece of HY-TEN A-Temper as rolled—bent cold.

HY-TEN is made in twelve distinct grades, thereby providing a steel suitable for practically every machine part.

Orders are assured prompt attention by our large and complete stocks carried in our warehouses.

WHEELOCK, LOVEJOY & CO.

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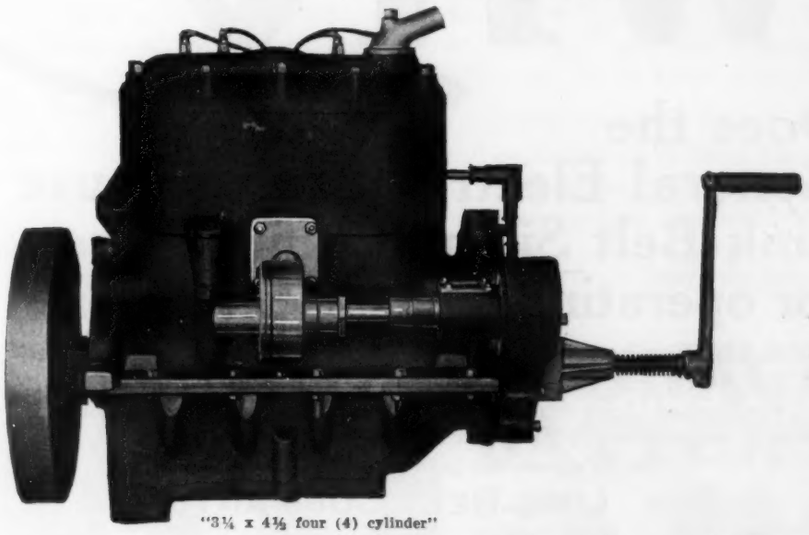
CAMBRIDGE, MASS.

1800-1802 Columbus Road
CLEVELAND, OHIO

Communicate with the nearest Office

MODEL H-D "LIGHT MOTOR" TRACTOR TYPE

A wonderful, economical motor



"3¼ x 4½ four (4) cylinder"

For the smaller type tractor the light motors are proving eminently satisfactory. Why? Strong, stiff crank shaft; large bronze back crank shaft and connecting rod bearings; water pump cooled; detachable cylinder head; light reciprocated parts; speed controlled by governor, and the HOTSPOT, are some of the features.

Write for complete specifications, prices, etc.

LIGHT MANUFACTURING & FOUNDRY CO.

POTTSTOWN, PA.

Why

Does the General Electric Company use a Link-Belt Silent Chain Drive for operating their "Genemotor"?

BECAUSE it has proved superior in the hard service expected of it on Ford cars. The construction of the patented Link-Belt Pin-Bushed Joint—an exclusive feature of Link-Belt Silent Chains—is largely responsible for the success of the drive.

Let our engineers help you solve your transmission problem.

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Before You Start

The man who has his battery tested *before he starts*, will not have to regret his negligence *after he stops*.

This does not mean simply "before you start on a long tour." It means "before you start each month," all the year round.

A few minutes at the Willard Service Station and you *know* your battery condition—You don't *guess* it's fully charged and filled with distilled water.

If your carburetor is out of adjustment you are warned by your engine at once, but if you are starving or overfeeding your battery it won't tell you—it will just suddenly quit *some day when you are miles out in the country*.

A Willard Battery with Threaded Rubber Insulation and a visit at the Willard Service Station once a month is the easiest and most direct road to starting and lighting dependability.

Reach for your desk calendar or pocket memo book right now, and jot down "battery" under some date each month, and you'll have a reminder.

Remember—a *dead battery* means a *dead engine*—but Willard Threaded Rubber Insulation plus Willard Service means starting and lighting satisfaction.

Willard Service.

Willard STORAGE BATTERY

Willard Threaded Rubber Insulation

"United"

AEROPLANE STEELS

Long experience in the manufacture of special steels enables us to produce with unusual success the difficult Chrome Nickel Steel for aeroplane parts.

One manufacturer recently made 6500 aeroplane crank-shafts from our high Nickel Chrome Steel without losing a single forging.

This is one reason why a large percentage of the parts in French and American fighting planes are made of "United" Alloy Steels.

United Alloy Steel Corporation

Canton, Ohio

Specialists in Alloy Steels

Searches for Engineering Data

THE Society of Automotive Engineers is in a position to give valuable assistance in conducting engineering searches along automotive lines, a comprehensive index to the Transactions of the Society greatly facilitating this work. Many of the more important engineering papers are available at small cost in pamphlet form.

The Society is in the same building with the United Engineering Society Library, which conducts searches on all engineering subjects, and to which inquiries of a highly specialized nature are referred. A charge of $1.50 an hour, is made to cover the cost of this work, but inquiries that necessitate little investigation are gladly answered without charge.

The Library contains 130,000 volumes, many of the reference works not being readily accessible elsewhere. Over 1000 technical journals and magazines, including every important engineering journal in the civil, mechanical, mining and electrical worlds, are kept on file. Photographic copies of articles in these journals will be furnished, as well as translations of articles in foreign languages.

You Can Use Our Equipment to Increase Your Production

Increased output does not require enlarging your own facilities. You can use ours —and save by doing it.

Unless your shop is an exception, every man and machine in it now engaged in finishing bushings, bearings and other small brass, bronze or aluminum castings represents a waste of time and energy.

Put these men and machines on better paying work—work that you can't get done so well or so cheaply elsewhere—and turn the job of supplying machined brass, bronze and aluminum parts over to us.

Other manufacturers have found that this not only has enabled them to boost their output but also to save money. For we specialize in this work and do the whole job of casting and machining.

That we have proved the soundness of this plan is indicated by the remarkable growth of our machine shop business, which now requires a plant containing 36,000 square feet of floor space.

You can quickly satisfy yourself about whether we can do what we claim and without spending a cent. Just let us quote on your next job.

Every Finished Piece Either Lynux or Lynite —In addition to other advantages mentioned, every casting turned out of our shops is made of either Lynux or Lynite. Lynux includes more than 100 standard brass and bronze alloys—Lynite a large number of aluminum alloys.

Let us send you our mailings on subjects of interest to users of bushings and bearings.

THE ALUMINUM CASTINGS COMPANY

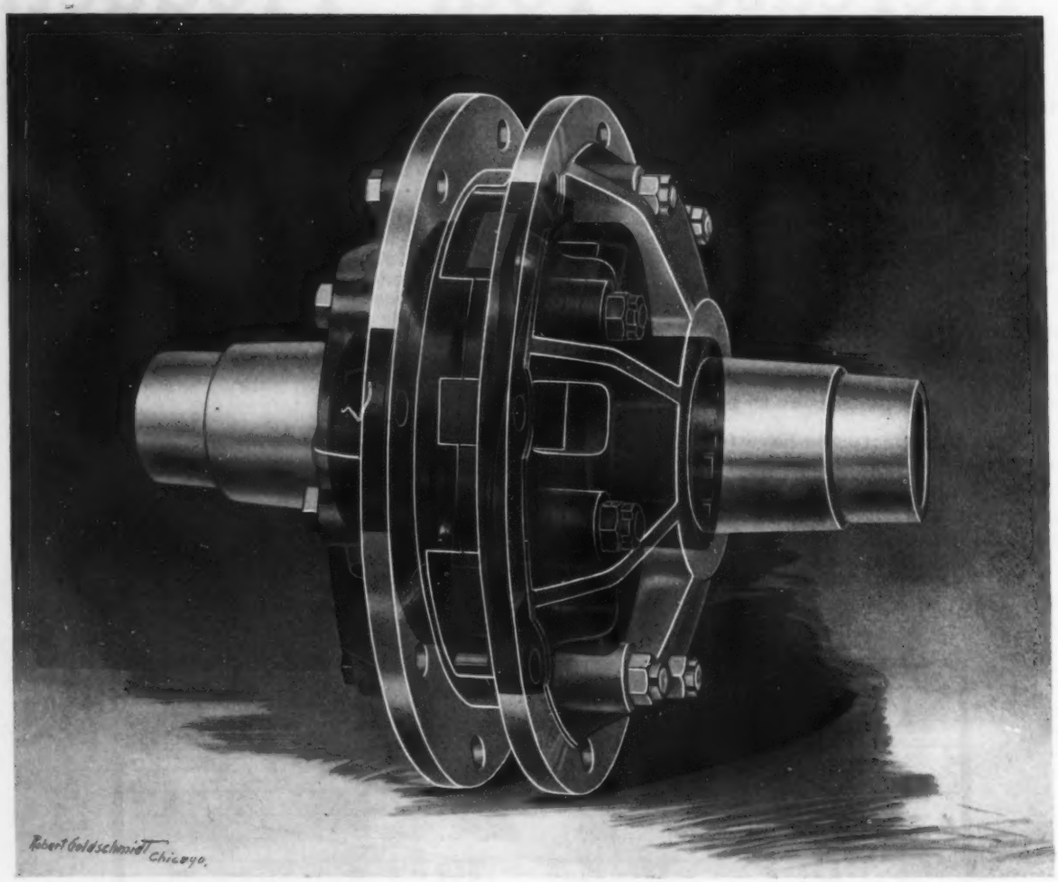
LYNITE and LYNUX Products

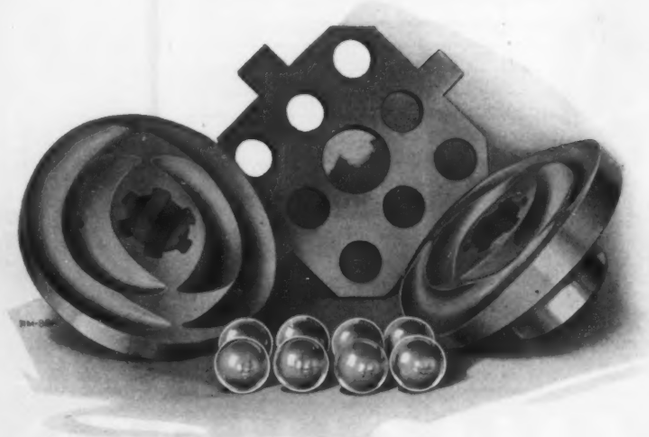
Eight Plants in

Cleveland Detroit Buffalo Manitowoc, Wis. Fairfield, Conn.

LYNUX AND LYNITE MACHINED PRODUCTS

The Dorr Miller Differential





A Uniform Pull—
A Positive Drive

is obtained through the use of the

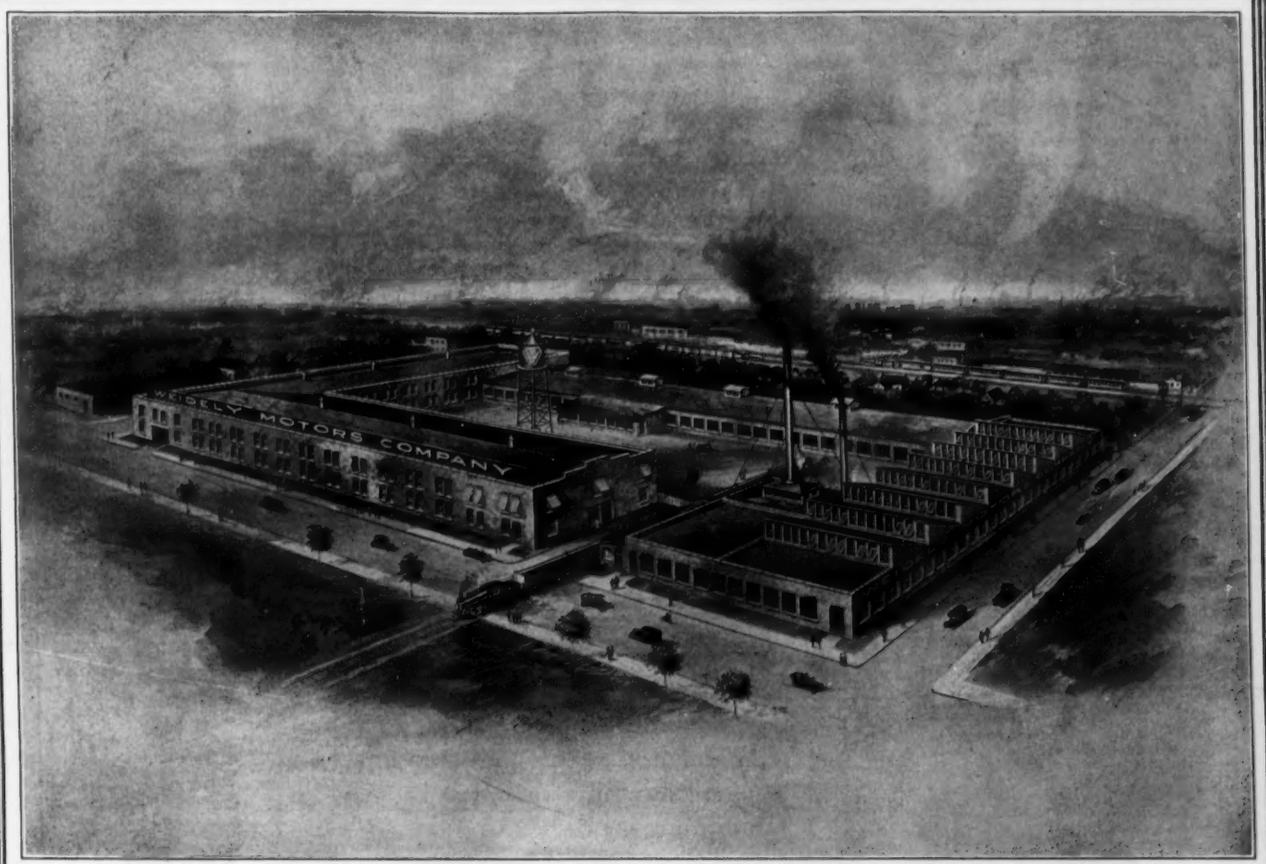
Dorr Miller Differential

Tests by some of the largest manufacturers of Commercial, Pleasure Cars and Tractors has resulted in its adoption as a standard.

What better recommendation of the value of a device can be obtained?

THE DORR MILLER DIFFERENTIAL CO.

Peoples Gas Bldg., Chicago 90 WEST ST., NEW YORK Factory, Detroit



85,000 FEET OF FLOOR SPACE DEVOTED ENTIRELY TO THE MANUFACTURE OF MOTORS

The Weidely Motors Company, when experience is considered, is probably the oldest firm making motor-building a specialty. All details of manufacture are under the direct supervision of G. A. Weidely, who, with the present organization, has been engaged in designing and building motors and automobiles for sixteen years, and the success of the "Weidely" Valve-In-Head Motors is the result of this experience.

THREE MODELS — FOUR SIZES

Model C 12 Cylinders 2⅞" Bore x 5" Stroke
Model M 4 Cylinders 3½" Bore x 5½" Stroke
Model M 4 Cylinders 3¾" Bore x 5½" Stroke
Model RM 6 Cylinders 4" Bore x 5½" Stroke

Simple—Accessible—Reliable

Weidely Valve-In-Head Motors have earned an enviable reputation and are fully guaranteed.

WEIDELY MOTORS COMPANY

INDIANAPOLIS, INDIANA, U. S. A.

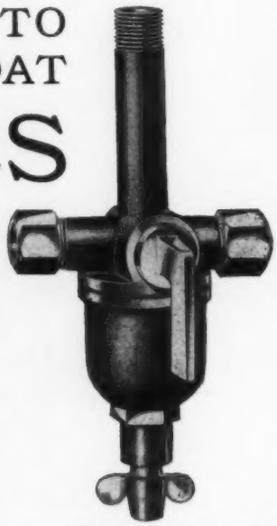
IMPERIAL

TRACTOR—TRUCK—AUTO AIRPLANE AND MOTOR BOAT SPECIALTIES

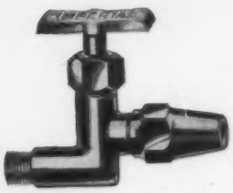
No. 119-J—Gasoline Strainer with reserve fuel supply feature and needle valve drain.

are made right! Forty years of experience in brass manufacturing and one of the largest and most modern plants in the central west are back of this assertion.

Imperial Manufacturing Service is being used to good advantage by many leading airplane, auto, truck, tractor and motor boat manufacturers. We make **anything** in brass, bronze or aluminum.



No. 120-J—Combination Shut-off Valve and Strainer for kerosene and gasoline, with needle valve drain.



No. 168 S. A. E. Needle Shut-off Valve. ¼" O. D. Tubing. ⅛" Iron Pipe Thread.

Other Imperial Specialties are:—

Gas Engine Primers
Shut-off and Priming Cocks
Compression Couplings
Three-Way Cocks
S.A.E. Tubing Fittings
Welding and Cutting Equipment
Manifolds (water and gas)
Carburetor Floats
Cast Bronze Name Plates
Needle Valves
Brass, Bronze and Aluminum Castings

Catalog and prices on request

No. 103-EF Needle Shut-off Valve. ¼" O. D. Compression, ⅛" Iron Pipe Thread

Airplane Auxiliary Hand Air Pump

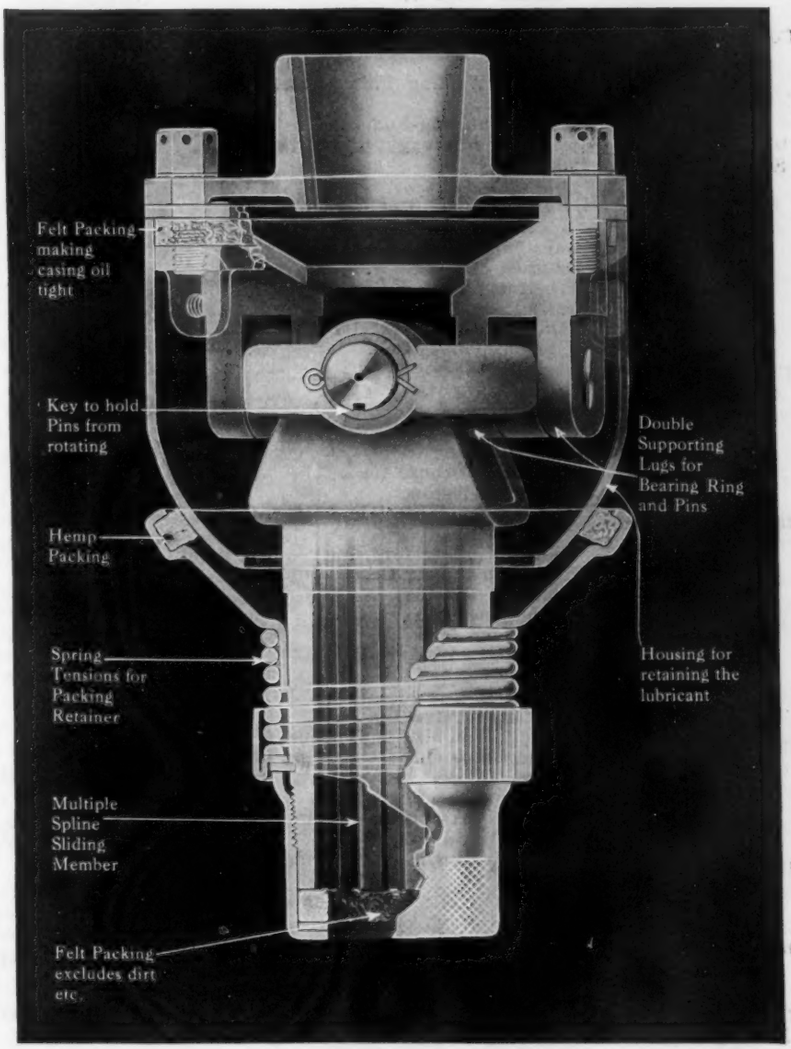
Special Manifold

Airplane Tank Filler Cap and Strainer Assembly

The Imperial Brass Mfg. Co.

531 South Racine Avenue Chicago

Hartford Hartford


Felt Packing making casing oil tight
Key to hold Pins from rotating
Hemp Packing
Spring Tensions for Packing Retainer
Multiple Spline Sliding Member
Felt Packing excludes dirt etc.
Double Supporting Lugs for Bearing Ring and Pins
Housing for retaining the lubricant

Hartford Auto Parts Co., Hartford, Conn.

Hartford Hartford

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The Skill of Patient Years That No Formula Can Give.

There is more to making a perfect alloy than a formula. Just as a good cook knows by an intuitive sixth sense just how to mix the batter to the right consistency, so must the expert metallurgical worker know just at what temperature to pour the various metals—just in what order—just how fast to let the mixture cool. The slightest variation one way or another causes some change in the smoothness of grain, the evenness of structure, that may lessen its value as an anti-friction metal. This knowledge that cannot be found in any formula is Mogul's by virtue of twenty years of specialization. It is the first of Mogul qualities that goes to make perfect engine bearings.

Mogul

Bronze Babbitt lined *and* Die Cast Bearings

Muzzy Lyon Company, Ltd.
Detroit, Michigan

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Weidely Motors Co.
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Continental Motors Corp.
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Waukesha Motors Co.
Weideley Motors Co.
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Fans, Radiator Cooling
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Wyman Gordon Co.
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Metals Welding Plant
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Generators, Ignition and Lighting
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Hydraulic Pressed Steel Co.
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Hubs, Wood Wheel
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Pistons, Cast Iron
Dall Motor Parts Co.
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Kinsler-Bennett Co.
Pyrometers, Optical
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Pyrometers, Recording
Leeds & Northrup Co.

The Index to Advertisers is given on pages 94 and 96

A Safe Choice

Automotive engineers in increasing numbers are recommending Rusco brake lining for factory equipment. Their own tests have proved Rusco a safe choice. You are probably one of these engineers. If you are you know how easily Rusco out-performs other brake linings.

If you aren't we'll be glad to send you samples. Examine them with exacting care—note the extra long fibre asbestos used as a base—the close, uniform weave possible only on special looms—the skillfully interwoven brass wire, expertly tempered and unbreakable. These are the reasons behind Rusco superiority.

Then put Rusco to the severest tests to which a brake lining can be subjected and you will see why its wide popularity among automotive engineers is still growing.

We also place at your disposal—without obligation to you—the co-operation of our engineering experts for any special work. May we serve you?

THE RUSSELL MFG. CO., Middletown, Conn.

349 Broadway, New York City 18 Alexandrine Avenue E., Detroit, Mich. 1438 Michigan Ave., Chicago, Ill.

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Prudden Wheel Co.
Standard Parts Co.

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Hood Tire Co., Inc.

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Oakley Chemical Co.

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Scovill Mfg. Co.

Screws, Machine
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Union Drawn Steel Co.

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Steels, Chrome Nickel
United Alloy Steel Corp.
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Wheelock, Lovejoy & Co.

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Washers, Oilless
Bound Brook Oil-less Bearing Co.

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Metals Welding Plant

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Automotive Wood Wheel Assn.
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Prudden Wheel Co.

Wire, Insulated
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Wrenches
Whitman & Barnes Mfg. Co.

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Our Regular Production Meets the Ordnance and Quartermaster Department Specifications

65% by volume. Plantation Hevea Rubber.
No "reclaimed rubber."
No "mineral" rubber.
Gravity stock, 1.90.
Strength, 2100-2500 lbs. per sq. inch.
Stretch, 500-575%.
Set, 30-36%.
Ages perfectly.
Road service excellent.

HOOD TIRE COMPANY, Inc.
WATERTOWN, MASS.

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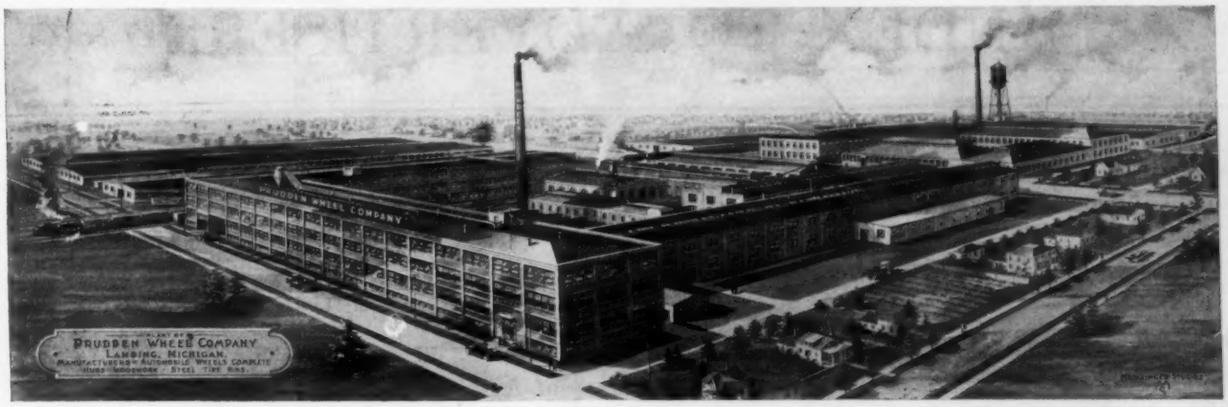

PRUDDEN WHEELS

Dependable Delivery

Our Aim:

To *promise* only what we can deliver.

To *deliver* all that we *promise*, and to do it on time.

Our Results:

In the past few months the necessity of taking care of the Government's needs has in some cases caused sacrifices on our part, resulting in inconvenience to commercial customers, but we are proud of *our record* of over 25,000 heavy truck wheels delivered for Government trucks this year.

The Future:

Closest co-operation is essential to insure safe wheel deliveries for the balance of 1918. Government needs are first and commercial customers must anticipate their needs as much as possible. *Our production capacity is increasing daily.*

For

Passenger Cars
Light Delivery Trucks
Truck Attachments
Heavy Trucks

COMPLETE WITH
WOODWORK—
HUBS — RIMS

PRUDDEN WHEEL COMPANY
MANUFACTURERS OF
Automobile Wheels Complete
LANSING, MICH.

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ENGINEERING SERVICE

THE members' professional cards appearing on page 2 form an index to professional service in all branches of the automotive industry. Through this section engineering service may be obtained relative to such subjects as:

Research Work
Automotive Design
Motor Transportation
Chemical Testing
Electrical Testing
Mechanical Testing
Automotive Testing
Testing Apparatus
Engine Investigation
Body Engineering

"INDEX TO ADVERTISERS' PRODUCTS"

THE items listed in the classified section of THE JOURNAL represent the products of the best-known companies connected with the automotive industry. Over 239 products manufactured by 135 companies are listed.

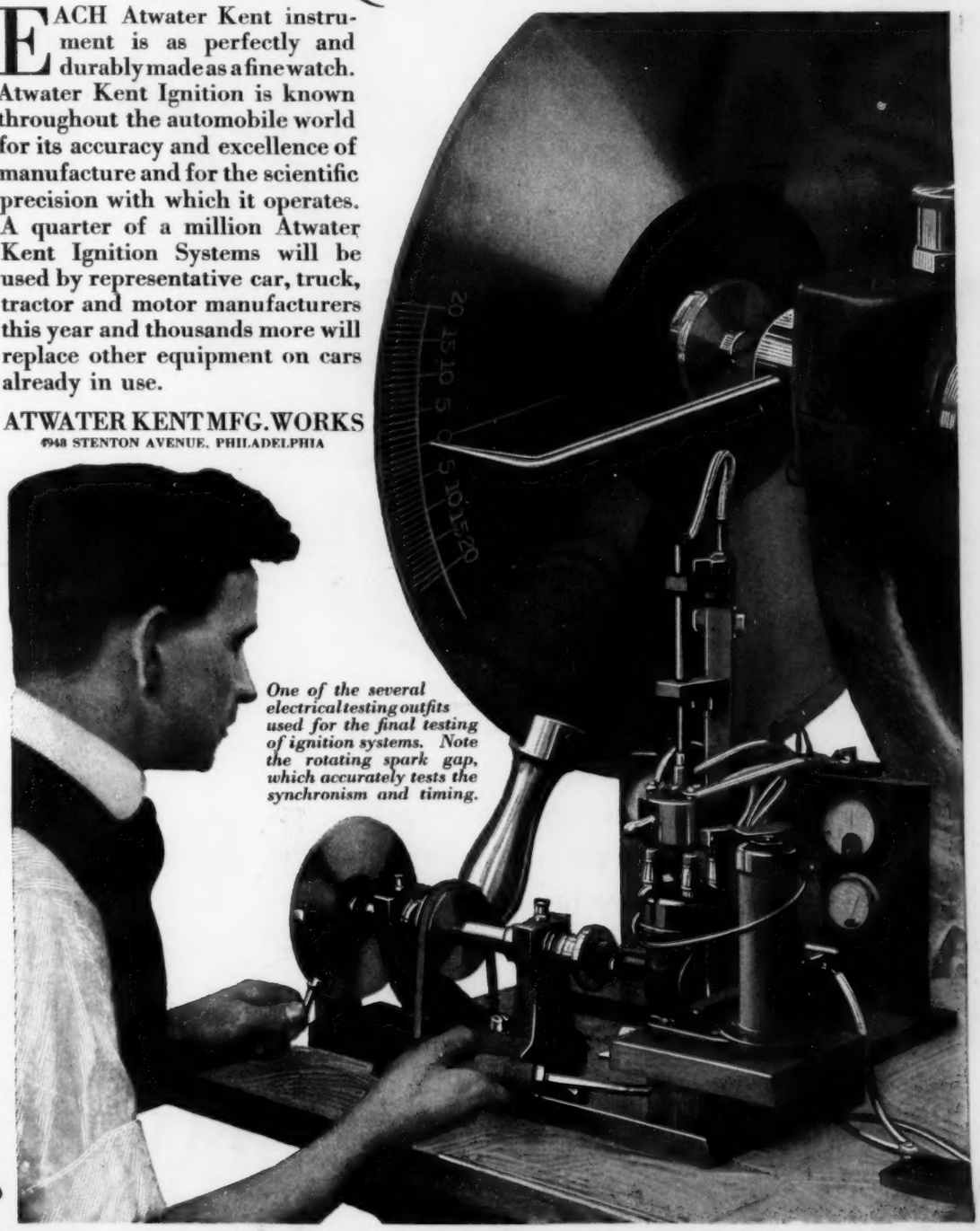
Every regular advertiser is entitled to and does have a certain number of his products listed in this "Index to Advertisers' Products." However, only those products which are of direct interest to the members of the Society are included.

S. A. E. Members are assured, therefore, that the list of products appearing on pages 88, 90 and 92 is there strictly for their benefit.

ATWATER KENT IGNITION

EACH Atwater Kent instrument is as perfectly and durably made as a fine watch. Atwater Kent Ignition is known throughout the automobile world for its accuracy and excellence of manufacture and for the scientific precision with which it operates. A quarter of a million Atwater Kent Ignition Systems will be used by representative car, truck, tractor and motor manufacturers this year and thousands more will replace other equipment on cars already in use.

ATWATER KENT MFG. WORKS
4948 STENTON AVENUE, PHILADELPHIA



One of the several electrical testing outfits used for the final testing of ignition systems. Note the rotating spark gap, which accurately tests the synchronism and timing.

MY SOLDIER

Now I lay me down to sleep
I pray the Lord my soul to keep.
God bless my brother gone to war
Across the seas, in France, so far.
Oh, may his fight for Liberty,
Save millions more than little me
From cruel fates or ruthless blast,–
And bring him safely home at last.

BUY WAR SAVINGS STAMPS

COMPLIMENTS OF
CURTISS AEROPLANE AND MOTOR CORPORATION

W.S.S. W.S.S.

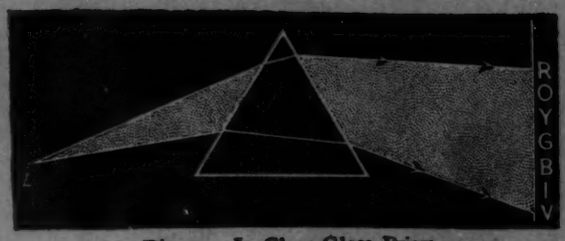


Diagram I—Clear Glass Prism

Diagram II—Noviol Glass Prism

How Noviol Glass adds to headlight efficiency

Why it provides new comforts in night driving

WHEN a beam of white light is refracted by a clear glass prism, it is analyzed into its constituent wave lengths. All the colors of the spectrum from red to violet appear on the screen. See Diagram I.

When a beam of light is refracted by a Noviol Glass prism, however, only the colors from red to green appear in the spectrum. Blue and violet do not register on the screen. This is because *Noviol Glass does not refract the blue and violet light waves, but absorbs them.* See Diagram II.

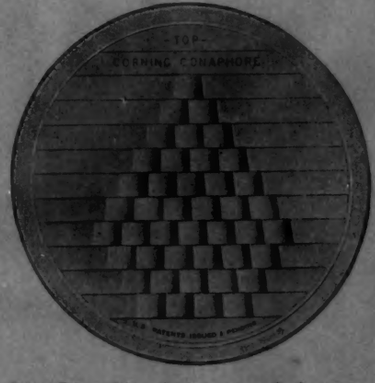
What this means to motorists

White light when projected by ordinary automobile headlights has marked disadvantages. All small particles (fog, dust, smoke and snow) diffuse light. The short blue and violet rays are the most easily diffused. These rays are mainly responsible for the annoying diffusion of light directly in front of a car, known as "back-glare."

Headlights equipped with Noviol Conaphores, however, project a beam of unique properties. By cutting out these blue and violet rays, the "back-glare" is largely reduced, and, accordingly, range of vision is much increased. *Noviol Glass—invented by Conaphore designers and patented—is the only glass ever produced that eliminates blue and violet rays without interfering with the efficiency of the beam.*

Signals "Safety" to others

Noviol light has many other advantages. It shows up the greens of the roadside in their natural colors.



The Conaphore has a smooth front surface. Easily cleaned. Does not clog with dust or mud

It defines a clear path when pavements are wet and glaring. More important still, it flashes a sure signal that the headlights will never dazzle an approaching motorist or pedestrian. All these advantages added to the no glare, long range features have established the Conaphore as the most efficient headlight glass among hundreds of thousands of motorists.

Automotive engineers and car manufacturers interested in headlighting problems are invited to consult us. The resources of our specially equipped laboratories and the knowledge of our technical glass experts are at your disposal.

Try out the Noviol Conaphore yourself Its extra advantages will be a distinct surprise.

Retail Price List (per pair)	Noviol Glass	Clear Glass
5 to 6½ inches incl.	$2.40	$1.60
7 to 8½ inches incl.	3.50	2.50
8½ to 10 inches incl.	4.50	3.00
10½ to 11½ inches incl.	6.00	4.00

Prices 25c. more per pair west of Rocky Mtr. Sizes vary by steps of ½ in. above 6½ in. size.

CONAPHORE SALES DIVISION
EDWARD A. CASSIDY CO., Mgrs.
Madison Avenue and 40th St. New York City

NO GLARE RANGE 500 FT. **CONAPHORE** **PIERCES FOG AND DUST**

CORNING GLASS WORKS—WORLD'S LARGEST MAKERS OF TECHNICAL GLASS